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A.O. No. OSSA-1-89

Announcement of Opportunity

Cassini Mission: Saturn Orbiter

Notices of Intent due: October 26, 1989

Proposals due: February 8, 1990

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3. Interdisciplinary Scientist investigations for data analysis, modeling, and science subgroup leadership. Such investigations require use of the data from a set of complementary instruments.

COORDINATED ANNOUNCEMENT OF OPPORTUNITY (AO)

The European Space Agency (ESA), through a coordinated AO, will solicit proposals for Principal Investigator/Instrument investigations for flight on the Huygens Probe and for Interdisciplinary Scientist investigations.

PLANNED SCHEDULE OF INVESTIGATION PROPOSAL AND SELECTION EVENTS

1989

October 26	Notices of Intent due.
November 9	Preproposal briefings for Saturn Orbiter (NASA AO) and Huygens Probe (ESA AO) at the European Space Research and Technology Centre, Noordwijk, The Netherlands.
November 15	Identical preproposal briefings at the California Institute of Technology, Pasadena, CA.

1990

February 8	Proposals due.
October 1	Tentative selection of investigations. Formation of Cassini Project Science Group (PSG).

1991

November	Confirmation and final selection of Saturn Orbiter investigations.

ANNOUNCEMENT OF OPPORTUNITY

FOR THE

CASSINI MISSION: SATURN ORBITER

AO NO. OSSA-1-89 October 10, 1989

I. INTRODUCTION

The National Aeronautics and Space Administration (NASA) announces the opportunity to propose scientific investigations for the Saturn Orbiter portion of the Cassini mission. The European Space Agency (ESA) also announces simultaneously, with a parallel Announcement of Opportunity (ESA AO SCI(89)2), the opportunity to propose scientific investigations for the Titan Huygens Probe portion of the Cassini mission. The NASA AO and the ESA AO are coordinated and on the same schedule.

The Cassini mission is a joint undertaking by NASA and ESA to explore the Saturnian system with a Saturn Orbiter and a Titan Probe. The complexities and cost of this ambitious mission call for a joint effort by the scientific and technological communities of Europe and the United States (U.S.). The launch vehicle and the Saturn Orbiter will be the responsibility of NASA, while the Huygens Probe System (the detachable Titan probe plus the orbiter-mounted probe support subsystem) will be the responsibility of ESA. The two agencies will share responsibility for project management and mission operations. Scientific instruments for the Probe and Orbiter payloads will be supplied by the international community. The Cassini mission is well-suited to a division of effort between two partners, and offers rich benefits to both the European and U.S. scientific communities.

The primary goal of Cassini, which is part of the NASA Comet Rendezvous Asteroid Flyby (CRAF)/Cassini Program, is to conduct an indepth, second-phase exploration of the Saturnian system. The CRAF/Cassini Program will be initiated in Fiscal Year 1990, leading to a Cassini spacecraft launch in 1996 on a Titan IV/Centaur launch vehicle. Upon arrival at Saturn, the Saturn Orbiter will deliver the Probe to Titan and will then make repeated close flybys of Titan both for scientific study and for gravity-assisted orbit torquing. During its four year nominal mission the Saturn Orbiter will make detailed observations of the Saturnian atmosphere, magnetosphere, ring system, and a number of its icy satellites. In addition, during its cruise phase the spacecraft will make close flybys of Jupiter and at least one main belt asteroid.

The Cassini mission is the second of the Mariner Mark II series of outer planet and primitive body missions recommended by the Solar System Exploration Committee (SSEC) as an essential element of the solar system exploration core program. The first of this series is the Comet Rendezvous Asteroid Flyby mission, for which investigations were

selected in October 1986. The Mariner Mark II spacecraft, now under development at the Jet Propulsion Laboratory, is modular in design, three-axis stabilized, and capable of cost-effective reconfiguration for each mission. In the Cassini configuration, instruments may be mounted to a scan platform for pointing, to a turntable for fields and particles measurements, to a ram direction platform for Titan aeronomy measurements, or directly to the spacecraft. Detailed information on spacecraft capabilities and constraints (see Section V) will be provided in Volume IV of the Proposal Information Package, a set of documents which will be sent to all those responding to this AO with a Notice of Intent to propose for the Saturn Orbiter portion of the Cassini mission.

The goal of Cassini is to carry out a mission with high scientific return and wide scientific participation within a relatively modest fixed cost envelope. The attainment of this goal will require a constrained selection of investigations, carefully planned sharing of spacecraft resources and capabilities, and sharing of reduced data sets. Cost and management constraints will place strict limits on the number and participation of science team members (see Section V.E.). Investigation selection will, in part, be based on consideration of 1) Investigation cost and cost risk; and 2) Spacecraft costs for instrument accommodation. Selected instruments that exceed the spacecraft baseline capabilities will be charged with the cost of required spacecraft modification. The total expected cost for an instrument investigation, as estimated by the Mariner Mark II Project Office, will be an important criterion in tentative selection and later in final selection (confirmation). This approach is reflected in Cassini program planning and by special provisions in this AO (see Sections V.D and VII.B).

This AO is open to the international scientific community. In view of the NASA/ESA cooperation on Cassini, proposals from non-U.S. institutions are strongly encouraged, but only on a no exchange of funds basis. Specific instructions for proposals from non-U.S. institutions are included in Section VI.

Internationally cooperative proposals, with Co-Investigators from U.S. institutions participating in non-U.S. proposals or with Co-Investigators from non-U.S. institutions on the teams of proposals from U.S. institutions, are also encouraged. These proposals must also be on a no exchange of funds basis and must identify any requirements for NASA financial support for U.S. personnel and/or hardware.

II. ANNOUNCEMENT OBJECTIVES

General scientific objectives for exploration of the outer planets, and of the Saturnian system in particular, have been established by the appropriate scientific advisory committees, including the Committee on Planetary and Lunar Exploration of the National Research Council's Space Science Board and the NASA Advisory Council's Solar System Exploration Committee (SSEC). The concept of Cassini as a combined Saturn Orbiter and Titan Probe mission, to be carried out as a joint NASA/ESA undertaking, was first proposed to ESA by a consortium of European scientists. Taking these earlier studies into account, specific objectives for the Cassini mission, including both the Saturn Orbiter and Titan Probe, were developed by the Cassini Joint Science Working Group with members

from Europe and the United States. For additional information, see Volume II (Cassini Phase A Report, SCI(88)5) of the Proposal Information Package.

Investigations proposed for the Saturn Orbiter portion of the Cassini mission must address one or more of the following scientific objectives. Those investigations which are more appropriate for the Huygens Probe portion of the mission must respond to the ESA AO.

SCIENTIFIC OBJECTIVES

The Saturnian System: The Primary Target of Cassini

TITAN

- Determine abundances of atmospheric constituents (including any noble gases), establish isotope ratios for abundant elements, constrain scenarios of formation and evolution of Titan and its atmosphere.

- Observe vertical and horizontal distributions of trace gases, search for more complex organic molecules, investigate energy sources for atmospheric chemistry, model the photochemistry of the stratosphere, study formation and composition of aerosols.

- Measure winds and global temperatures; investigate cloud physics, general circulation, and seasonal effects in Titan's atmosphere; search for lightning discharges.

- Determine the physical state, topography, and composition of the surface; infer the internal structure of the satellite.

- Investigate the upper atmosphere, its ionization, and its role as a source of neutral and ionized material for the magnetosphere of Saturn.

SATURN

- Determine temperature field, cloud properties, and composition of the atmosphere of Saturn.

- Measure the global wind field, including wave and eddy components; observe synoptic cloud features and processes.

- Infer the internal structure and rotation of the deep atmosphere.

- Study the diurnal variations and magnetic control of the ionosphere of Saturn.

- Provide observational constraints (gas composition, isotope ratios, heat flux,...) on scenarios for the formation and the evolution of Saturn.

- Investigate the sources and the morphology of Saturn lightning (Saturn Electrostatic Discharges (SED), lightning whistlers).

RINGS

- Study configuration of the rings and dynamical processes (gravitational, viscous, erosional, and electromagnetic) responsible for ring structure.

- Map composition and size distribution of ring material.

- Investigate interrelation of rings and satellites, including embedded satellites.

- Determine dust and meteoroid distribution both in the vicinity of the rings and in interplanetary space.

- Study interactions between the rings and Saturn's magnetosphere, ionosphere, and atmosphere.

ICY SATELLITES

- Determine the general characteristics and geological histories of the satellites.

- Define the mechanisms of crustal and surface modifications, both external and internal.

- Investigate the compositions and distributions of surface materials, particularly dark, organic rich materials and low melting point condensed volatiles.

- Constrain models of the satellites' bulk compositions and internal structures.

- Investigate interactions with the magnetosphere and ring systems and possible gas injections into the magnetosphere.

MAGNETOSPHERE OF SATURN

- Determine the configuration of the nearly axially symmetric magnetic field and its relation to the modulation of Saturn Kilometric Radiation (SKR).

- Determine current systems, composition, sources, and sinks of magnetosphere charged particles.

- Investigate wave-particle interactions and dynamics of the dayside magnetosphere and the magnetotail of Saturn and their interactions with the solar wind, the satellites, and the rings.

- Study the effect of Titan's interaction with the solar wind and magnetospheric plasma.

- Investigate interactions of Titan's atmosphere and exosphere with the surrounding plasma.

Targets of Opportunity

ASTEROID FLYBY

- Investigate an asteroid not seen by previous missions, possibly a new class of asteroid, thereby adding important new information to the study of asteroids.

- Characterize global properties, determine composition and morphology of the surface, investigate properties of the regolith.

JUPITER FLYBY

- Extend the time for studies of atmospheric dynamics and variable satellite phenomena, specifically Io volcanism, beyond the period accessible to the Galileo nominal mission.

- Infer global atmospheric thermal structure and composition with instrumentation not carried by the Galileo Orbiter, complementing the local in situ measurements of the Galileo Probe.

- Explore the dusk side of the magnetosphere and intermediate regions of the magnetotail unvisited by previous spacecraft.

- Obtain the first high-resolution images of the Io torus.

CRUISE SCIENCE

- Extend the sensitivity of composition measurements of interstellar ions by approximately three orders of magnitude.

- Investigate the behavior of the solar wind during solar minimum, for comparison with earlier Galileo and Ulysses measurements.

- Extend spacecraft searches for gravitational waves.

- Extend studies of interplanetary dust to the orbit of Saturn.

- Attempt to detect internal oscillations of Saturn, Jupiter, and some stars.

Investigations addressing other scientific objectives which take advantage of the unique characteristics of the Cassini mission will also be considered, but at lower priority.

III. DESCRIPTION OF THE OPPORTUNITY

A. TYPES OF PROPOSALS

This Announcement solicits proposals for scientific participation in the Saturn Orbiter portion of the Cassini mission. Investigators wishing to propose for the Huygens Probe, which descends into the atmosphere of Titan, must respond to the ESA Announcement of Opportunity. Proposals for participation in the Saturn Orbiter portion of the mission may describe investigations which utilize data to be obtained by both Saturn Orbiter and Huygens Probe instruments. Such synergistic investigations are encouraged, and will be carried out within the framework of the Cassini Project Science Group (PSG) (See Section III.E).

For the Cassini Saturn Orbiter mission, four (4) types of scientific participation are envisioned; these are described below. This AO invites proposals for the first three (3) types, while proposals for the fourth type will be invited at a later time.

1. Principal Investigator/Instrument Proposals

This type includes investigations that involve the provision of a scientific instrument to be carried on the Saturn Orbiter and the analysis and interpretation of data from that instrument by a group of scientists. Prospective participants must designate in their proposals a single Principal Investigator (PI) and a limited number of Co-Investigators (Co-I's), each of whom must have a well-defined role that is specified and justified in the proposal. The designation "Co-Principal Investigator" is not permitted, nor is the listing of additional "associated" scientists.

PI/Instrument proposals may include optional enhancements to the baseline instrument, but any such options must be fully described and costed.

2. Facility Instrument Team Leader/Team Member Proposals

This type includes investigations by individual scientists using Facility Instruments that may be selected for the Cassini Saturn Orbiter. NASA is planning that four Facility Instruments will be provided: an Imaging Science Subsystem (ISS), a Visual and Infrared Mapping Spectrometer (VIMS), a Titan Radar Mapper (RADAR), and a Radio Science Subsystem (RSS). The RSS will consist of certain portions of the spacecraft Radio

Frequency Subsystem (RFS) and any other hardware elements optionally added to the RFS to enhance its performance for radio science purposes. Background information and brief descriptions of these Facility Instruments are given in Section V.C.2, while more detailed information is contained in Volumes VI, VII, VIII, and IX of the Proposal Information Package.

Individuals may propose to be the Team Leader (TL) or a Team Member (TM) on NASA-formed teams using these Facility Instruments (ISS, VIMS, RADAR, and RSS) for scientific investigations. Individuals proposing to be Team Leader will also be considered for Team Member in the event they are not selected as Team Leader; if they do not wish to be so considered, they should so state in their proposals. Proposers should indicate the specific skills and capabilities that they will bring to the Facility Instrument Team and why they should be involved with the Facility Instrument from development activities through data analysis. <u>They must propose to carry out a scientific investigation with data from the Facility Instrument leading to publication of results.</u> In addition, they should propose to participate in such activities as science planning, final instrument definition, operations, data management, data analysis, calibration, and algorithm development. Individuals may propose to participate on more than one team through the submission of more than one proposal. In preparing their proposals, prospective Team Leaders or Team Members should note the following conditions (which are discussed in more detail in Sections V.C.2 and VI.B):

(a) Final decisions regarding the inclusion of particular Facility Instruments in the Saturn Orbiter payload and use of the RFS for radio science investigations will be made by NASA after the review of proposals received in response to this AO, the tentative selection of investigations, and the completion of the Science Confirmation Review (see Section VII.B).

(b) NASA will consider PI/Instrument proposals which address science objectives similar to those addressed by the candidate Facility Instruments. The decision as to whether to proceed with a Facility Instrument or with a competing PI/Instrument investigation will be made as part of the selection and confirmation process, with both quality of the proposed investigation and cost being key considerations.

(c) <u>Proposals for Team Leader or Team Member must be submitted by individuals. Proposals from teams or groups of investigators will not be considered.</u> However, individual proposers may include the participation of a limited number of appropriate support personnel in their proposal.

(d) An individual may submit <u>both</u> a PI/Instrument proposal whose science goals are similar to those addressed by a candidate Facility Instrument <u>and</u> a proposal to be Team Leader on that Facility Instrument Team. Proposers of instruments in competition with Facility Instruments whose investigations are not selected may be appointed as Team Members without having submitted proposals specifically for that purpose; if they do not wish to be so considered, they should so state in their proposals. Similarly, if a PI/Instrument proposal is selected in place of a Facility Instrument, NASA reserves the right to appoint additional members to the proposed investigation team to be selected from

those who submitted proposals for Team Leader, Team Member, or other PI instruments. Prospective PI's should indicate in their proposals their willingness to accept such additions.

3. Interdisciplinary Scientist Proposals

This type includes investigations by individuals who wish to perform interdisciplinary investigations requiring use of the data from a set of complementary instruments and who also wish to participate in all phases of the mission, including: definition, science planning, operations, data analysis, data management, and publication of results. Interdisciplinary Scientist (IDS) proposals must be submitted by individuals. Proposals from teams or groups of investigators will not be considered. However, individual proposers may include the participation of a limited number of appropriate support personnel in their proposal.

NASA plans to select a limited number of Interdisciplinary Scientists in such fields as: Satellites and Asteroids, Rings and Dust, Magnetosphere and Plasma, Atmospheres, and Origin and Evolution. Each IDS will be selected on the basis of the scientific quality and value of the investigation proposed and on the ability of the IDS to support the Project by maintaining a broad and critical scientific overview of mission activities during the planning and operations phases of the Cassini mission.

The ESA Announcement of Opportunity for Huygens Probe investigations also invites Interdisciplinary Scientist proposals. ESA plans to select IDS's in one or more of the following fields: Titan Aeronomy, Titan Atmosphere/Surface Interactions, and Titan Atmospheric Composition and Chemistry.

Current plans envision that each IDS will chair a subgroup of the Cassini Project Science Group (PSG) (see Section III.E). These subgroups will be responsible for activities and advisory functions in particular interdisciplinary areas, such as those listed above. IDS proposers should indicate their interest in one of these or in other appropriate areas. They should describe both their qualifications and their specific plans (1) for carrying out their proposed scientific investigations and (2) for supporting the Project by leading an appropriate subgroup during all phases of the mission.

4. Participating Scientist Proposals

This type includes investigations that are either instrument-specific or interdisciplinary, carried out by scientists who wish to participate only in the data collection and analysis phases of the mission. Each individual whose investigation is selected will be designated as a Participating Scientist (PS) and may be attached to existing teams or groups if and when appropriate, either prior to launch or during the operations phase of the mission. Proposals for Participating Scientist are not solicited by this AO, but will be the subject of one or more future announcements.

It is anticipated that most PS opportunities will coincide with such mission phases as the asteroid and Jupiter flybys and the Orbiter tour of the Saturnian system (see Announcement Objectives, Section II). NASA will, however, consider proposals for other high quality science activities that could use the existing Saturn Orbiter payload to address other scientific goals, to the extent that such other activities can be accommodated without compromising the basic objectives of the Cassini mission.

At this time, proposals are solicited only for investigations listed under items 1, 2, and 3 above.

B. COORDINATION WITH THE ESA ANNOUNCEMENT OF OPPORTUNITY

The development and issuance of this NASA AO for the Saturn Orbiter has been coordinated with the parallel development and issuance of the ESA AO for the Huygens Probe. The evaluation of proposals and selection of Saturn Orbiter and Huygens Probe investigations will be similarly coordinated. Copies of the ESA AO may be obtained from:

Dr. J-P. Lebreton
Huygens Project Scientist
P.O. Box 299
2200 AG Noordwijk
The Netherlands
Telex 39098

Investigators at U.S. institutions who wish to respond to the ESA AO and who require NASA financial support must submit a copy of their proposal, including a Management and Cost Plan, to NASA Headquarters in order to obtain NASA funding endorsement. This also applies to Co-Investigators from U.S. institutions participating in non-U.S. proposals being submitted in response to either AO.

C. SCHEDULE

A written Notice of Intent, signifying the writer's intent to submit a proposal in response to this AO, is due at NASA Headquarters on or before October 26, 1989. Details are given in Section VI.A.

Individuals who submit Notices of Intent will then be sent a Proposal Information Package consisting of documents which provide details about the Mariner Mark II Project and spacecraft, the Saturn Orbiter part of the Cassini mission, and other information needed to prepare the proposal. Details of the contents of this package are given in Section VI.A.

Preproposal briefings will be held on November 9, 1989, at the European Space Research and Technology Centre (ESTEC), Noordwijk, The Netherlands, and on November 15, 1989, at the California Institute of Technology in Pasadena, CA, in order to provide additional information to prospective proposers. The purposes of these briefings, which are

planned to be identical and which will cover both the Saturn Orbiter and the Huygens Probe System, will be to present details of the Cassini mission and to respond to any questions that potential proposers may have. Further information concerning these meetings will be sent to individuals who respond with a Notice of Intent and to others who request this information in writing from the CRAF/Cassini Program Scientist at NASA Headquarters (for address see Section VI.A.1). Individuals who plan to attend either of the Preproposal Briefings should advise NASA (Cal Tech Briefing) or ESA (ESTEC Briefing) of their planned attendance so that the anticipated total attendance can be estimated and appropriate arrangements made (see Section VI.A.3). NASA does not provide travel funds for attending either of these briefings.

Proposals must be received at the NASA Headquarters address given in Section VI.A.1 on or before 4:30 pm (EST) February 8, 1990.

The tentative selection of investigations is planned to take place on October 1, 1990.

Confirmation and final selection of Saturn Orbiter investigations is planned to occur during November 1991.

D. PHASED IMPLEMENTATION OF INVESTIGATIONS

There is a chance that proposed investigations and instrument designs may not be fully compatible with the Mariner Mark II spacecraft and/or the selected payload. Therefore, immediately after the tentative selection of investigations, an Investigation Accommodation Phase of approximately 13 months duration will take place. Allocations of critical spacecraft resources (e.g., mass, power, data rate, etc.) will be assigned to each selected instrument immediately after the tentative selection. These allocations are necessary to minimize risk to the spacecraft development that has taken place ahead of the selection and confirmation process.

During this Investigation Accommodation Phase, each instrument in the tentatively selected Saturn Orbiter payload will be reviewed for cost and compatibility with its assigned spacecraft resource allocation. All tentatively selected investigations, including those of Team Leaders, Team Members, and Interdisciplinary Scientists, will be reviewed for cost, compatibility with the spacecraft, and compatibility with the final payload to be selected. For purposes of cost control, it is required that, during this period, thorough efforts be made to identify and resolve areas of potential cost growth within investigations and/or cost growth that results from investigation requirements on the spacecraft or on other mission systems. Individual resource allocations may be revised by the Mariner Mark II Project if, in that process, the overall resource budget is not exceeded.

NASA does not plan to deliberately proceed with an oversubscribed Saturn Orbiter payload into the Investigation Accommodation Phase of the Cassini mission. However, after review and evaluation of proposals submitted in response to this AO, NASA may tentatively select, for further evaluation during the Investigation Accommodation Phase, more than one investigation that addresses a similar set of science objectives. In such a case, a final decision on the selection of such investigations will be made at the end of the

Investigation Accommodation Phase, as part of the process of final confirmation and selection of the investigations and the Saturn Orbiter payload (see Section VII.B). Incompatibilities between investigation requirements and spacecraft resources identified during the Investigation Accommodation Phase may preclude proceeding with the full set of investigations that has been tentatively selected.

Final selection and confirmation of all investigations will take place at the conclusion of the Investigation Accommodation Phase. A Science Confirmation Review, followed by final selection of investigations, is planned for November 1991.

E. FORMATION OF CASSINI PROJECT SCIENCE GROUP

After tentative selection of the investigations, a Cassini Project Science Group (PSG) will be established. All Saturn Orbiter and Huygens Probe Principal Investigators, all Team Leaders of Orbiter Facility Instruments, and all Interdisciplinary Scientists will automatically become members of the Cassini PSG, including those selected through both the NASA and ESA processes. The Cassini PSG will be chaired by the Cassini Project Scientist. The PSG will meet regularly throughout the lifetime of the mission and will work with the Cassini and Huygens Project Scientists, the CRAF/Cassini Program Scientist, and the Mariner Mark II and Huygens Project Managers to optimize mission science return and to resolve conflicts among requirements. Responsibilities of the Cassini PSG members are described in detail in Volumes XI and XII of the Proposal Information Package.

F. SUBSEQUENT ANNOUNCEMENTS

One or more additional opportunities to participate in the Cassini mission as a Participating Scientist (PS) will be announced later. The release of these announcements will be timed to permit selection of PS investigations for appropriate planning and data-gathering periods. These opportunities will also serve to encourage coordination among the Cassini, CRAF, and Galileo missions, thereby enhancing the science return from all three. The Cassini and CRAF asteroid flybys occur in March 1997 and January 1998, respectively, suggesting a joint PS opportunity. The Cassini flyby of Jupiter occurs in February 2000, suggesting a PS program to relate flyby results to Galileo data gathered during the 1996-97 nominal mission and any extended Galileo mission. NASA also plans to establish an Outer Planets Data Analysis Program, open to the international community, commencing with the first public availability of Galileo data in 1996 and continuing at least through the Cassini Jupiter flyby in 2000.

IV. MISSION BACKGROUND

The Cassini mission will explore the Saturnian system, which contains a host of volatile-rich bodies and a record of the processes that have modified them. Remote measurements of the composition of Saturn's atmosphere will provide information about the original elemental and isotopic composition of the solar nebula. Images of the surfaces

of the icy satellites of Saturn will reveal a record of early solar system accretionary, heating, and cratering processes. Long-term remote observations of the rings will provide data about collisional, gravitational, and plasma processes that were important in the early stages of planet formation. Measurements of the surface and atmospheric composition of Titan will yield information on prebiotic chemical processes in planetary atmospheres, some of which resemble processes that may have operated in Earth's primitive atmosphere. Observations of Saturn's magnetosphere, and of Titan's interaction with it, will provide information on plasma processes that have application to many astrophysical settings. The Cassini mission thus promises to provide a wealth of new data vital to furthering the current understanding of chemical and physical processes involved in the formation and evolution of the solar system.

In its 1975 report on space science, the Space Science Board of the National Research Council and its Committee on Planetary and Lunar Exploration (COMPLEX) recognized that "the outer planets and their satellites represent a wholly new class of planetological problems, which are fundamental to the understanding of the formation of the solar system and about which we have little information." COMPLEX recommended that an indepth exploration of Jupiter and its satellites be achieved by 1985 (Galileo) and that, further, NASA position itself to undertake a detailed exploration of the Saturnian system subsequent to the Pioneer and Voyager reconnaissance missions. These objectives, together with those formulated by COMPLEX for the investigation of the terrestrial planets and the primitive bodies, have provided the scientific basis for development of an implementation strategy for NASA's solar system exploration program.

In order to address the implementation of these recommendations, the NASA Advisory Council in 1980 formed the Solar System Exploration Committee (SSEC) to develop a mission strategy for the planetary program through the end of the century. The 1983 report of the SSEC recommended a new generation of scientifically vital, yet affordable, solar system exploration missions that would be consistent with the scientific recommendations of COMPLEX while taking advantage of spacecraft hardware inheritance, development of a multimission operations system, and other cost-saving measures.

The SSEC report recommended an initial sequence of four core missions. The first of these, the Venus Radar Mapper (now Magellan) is on its way to Venus. The second, the Mars Observer, is under development. CRAF, the third mission, has a tentatively selected payload and will be the first mission to use the Mariner Mark II spacecraft. The Cassini mission results from combining the fourth SSEC recommended initial core mission (Titan Probe/Radar Mapper) with the committee's highest priority outer planet mission (Saturn Orbiter) in the subsequent core mission group. This combined mission, and the name Cassini, were first proposed to ESA by a consortium of European scientists in 1982; the proposers suggested at that time that the mission be carried out in collaboration with NASA. In that same year, the Space Science Committee of the European Science Foundation and the Space Science Board of the U.S. National Academy of Sciences set up a Joint Working Group (JWG) to study possible cooperation between Europe and the United States in the area of planetary exploration. In its 1986 report, one of the potential cooperative missions recommended by the JWG was a Saturn Orbiter and Titan Probe mission.

In 1986 COMPLEX updated its strategy for outer planets exploration. Based on the assumptions that by 1990 Voyager will have completed flybys of all the giant planets, and that the Galileo probe and orbiter will have been launched to Jupiter, the Committee wrote that "the highest priority for outer planet exploration in the next decade is intensive study of Saturn--the planet, satellites, rings, and magnetosphere--as a system."

During 1986, the prospects for timely NASA/ESA cooperation on Cassini materialized: NASA announced the initiation of a Cassini Phase-A study, and later that year ESA's Science Programme Committee (SPC) approved a Phase-A study for the Cassini Titan Probe. In 1987 and 1988, NASA carried out further definition work on the Mariner Mark II spacecraft and on the first two missions designed to use it, CRAF and Cassini. The Cassini Joint Science Working Group (JSWG), with membership appointed by NASA and ESA, supported these studies. The report of the Cassini JSWG, along with an addendum including some later work, will be provided as Volume II of the Proposal Information Package.

In early 1988, NASA combined CRAF and Cassini into a single (CRAF/Cassini) program and later that year requested new start approval. ESA approved its contribution to Cassini in November 1988, and named its contribution to the program the Huygens Probe. The CRAF/Cassini new start was included in the President's Fiscal Year 1990 budget request to Congress in January 1989.

V. REQUIREMENTS AND CONSTRAINTS

A. BASELINE MISSION DESCRIPTION

The Cassini spacecraft (Orbiter/Probe) will be launched on a Titan IV/Centaur launch vehicle in April 1996. The trajectory will include a gravity-assist flyby of Earth in June 1998, and a subsequent flyby of Jupiter in February 2000. In addition, a close flyby of a main belt asteroid will be conducted during interplanetary cruise; the current target is 66 Maja, with the flyby occurring about one year after launch. This sequence of events will result in arrival at Saturn in December 2002. During the initial approach to Saturn the spacecraft will make a flyby of the satellite Phoebe.

The Saturn orbit insertion maneuver will occur near periapsis at about 1.3 Saturn radii (R_S), and will place the spacecraft in a highly elliptical orbit with a period of about 100 days. Near apoapsis of this orbit another maneuver will raise periapsis to about 9 R_S, and will place the spacecraft on a Titan impact trajectory. About 12 days before Titan encounter, the Probe will be properly oriented for Titan entry, and then spun up and separated from the Orbiter. Approximately two days later, the Orbiter will perform a deflection maneuver to establish the proper flyby geometry for both the Probe data relay and the start of the orbital tour of the Saturn system.

Huygens Probe entry will occur in March 2003. All of the Probe mission data will be transmitted to the Saturn Orbiter, which will be executing a flyby of Titan with a closest

approach altitude of 1500-2500 km. The Orbiter will immediately relay the data to Earth and will simultaneously record the data for later playback.

Following the Huygens Probe mission, the Orbiter will continue on a tour of the Saturnian system. The tour duration will be four years, from Saturn orbit insertion to the end of the nominal mission. This will allow approximately 60 Saturn orbits, the size and orientation of which will be controlled by Titan gravity-assist flybys. There will be approximately 35 Titan flybys during the four-year tour, providing many opportunities for Titan science acquisition.

There will be many nontargeted encounters with Saturn's icy satellites during the tour; in addition, Titan gravity assist will be used to target the spacecraft for close flybys of some of these satellites. Both equatorial and inclined orbits will allow extensive coverage of Saturn's atmosphere and magnetosphere. Inclined orbits will also allow high-resolution imaging of Saturn's rings, as well as creating periods of Saturn and ring occultations. The nominal mission will end in December 2006 with the spacecraft in a near-polar Saturn orbit. An extended mission, including additional Titan flybys, may be possible if sufficient navigation and attitude control propellants are available.

1. Interplanetary Trajectory. The heliocentric spacecraft trajectory for an April 1996 launch to Saturn is illustrated in Figure 1. Following launch, the spacecraft will be placed on an Earth return trajectory. Two maneuvers will be performed before the spacecraft encounters Earth a little over two years after launch. The Earth flyby will give the spacecraft sufficient energy to reach Jupiter in the year 2000. The Jupiter flyby will provide another gravity assist and enable the spacecraft to travel on to Saturn.

2. Asteroid Flyby. The spacecraft trajectory will enter the asteroid belt twice, first on the Launch-Earth return leg and again on the leg from Earth to Jupiter. A survey was made of the asteroids that pass close to the trajectory to determine if a flyby of a specific asteroid could be incorporated into the baseline mission design. The result of this study is the inclusion of a flyby of the C-type asteroid 66 Maja (radius 39 km) on March 29, 1997 (see Figure 2).

This flyby will occur very near solar superior conjunction; thus, the Doppler signal available for asteroid mass determination will be degraded by passage of the signal through the solar corona. This may result in an asteroid mass uncertainty of 50% or greater, depending on the solar activity level. The flyby date could be altered to avoid the conjunction region, but the impact on mission performance and on the other science objectives is presently judged to be too severe.

The flyby of 66 Maja is particularly attractive because of the relatively low flyby speed (about 6.5 km/s). Approach will be from the sunlit side, and closest approach will be near the terminator. The flyby distance will be selected based on the science objectives and on spacecraft safety considerations, and is presently set at 85 asteroid radii, or about 3400 km. The inclusion of an asteroid flyby has a significant effect on the mission design, and implies some tradeoff among asteroid science and the other science objectives. Future considerations may involve reassessment of the asteroid selection or possible inclusion of

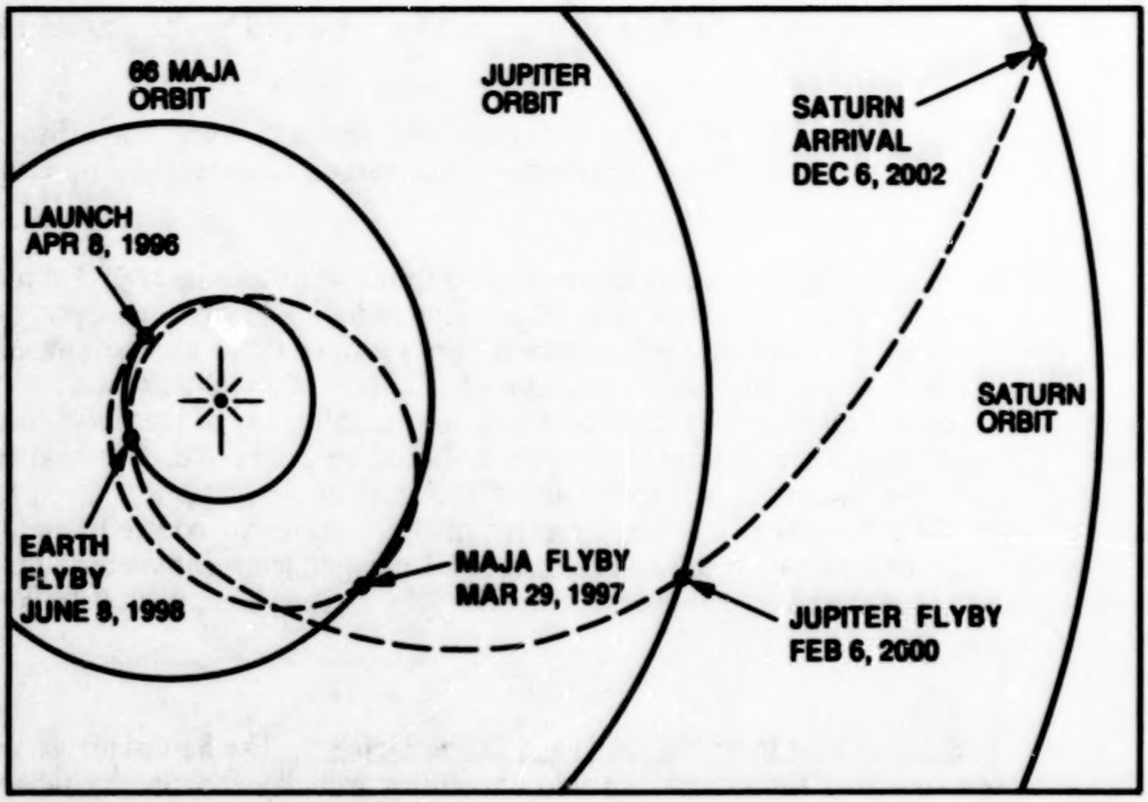

Figure 1. Cassini 1996 Baseline Trajectory

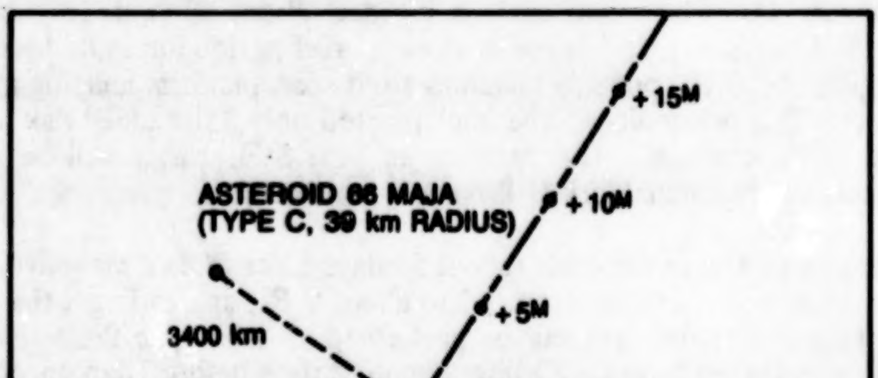

Figure 2. Baseline Mission Flyby of Asteroid 66 Maja

a second flyby target. Details of the flyby strategy will be developed by the Cassini PSG and the Mariner Mark II Project.

Following the flyby of 66 Maja, the spacecraft will return to Earth for a flyby at 300 km altitude on June 8, 1998. This will place the spacecraft on a Jupiter flyby trajectory.

3. Jupiter Flyby. Closest approach to Jupiter will occur in early February 2000, at a distance of about 54 Jovian radii (R_J). The radiation environment poses no threat at this distance. The mission performance is very sensitive to the Jupiter aimpoint, so there is no possibility of perturbing the trajectory for a flyby of a Galilean satellite. In addition, there does not appear to be an opportunity to encounter any of the outer Jovian satellites. However, significant Jupiter flyby science should be achievable. For example, as Figure 3 shows, the spacecraft will spend about 130 days in the magnetotail, out to a distance of over 1300 R_J. This is a much greater distance than that covered by either Galileo or Voyager, and will allow the magnetotail to be mapped more completely. Other remote sensing science may be conducted during the flyby to complement measurements made by Galileo.

4. Saturn Orbit Insertion (SOI) and Probe Delivery. The Saturn arrival date has been chosen to allow the closest possible encounter with Phoebe on the inbound trajectory. The distance of closest approach to Phoebe will be about 360,000 km and will occur about 17 days before arrival at Saturn. Upon arrival, the spacecraft will be inserted into an initial highly eccentric orbit with a period of 100 days and a periapsis radius of 1.3 R_S (see Figure 4). The initial orbit is inclined about 20° with respect to Saturn's equator. The SOI burn may be delayed to allow a brief period for limited science acquisition in the region of 1.3 R_S, possibly including fixed scan platform imaging and fields and particles science. This possibility will be implemented only if the added risk to the mission is determined to be minimal. The decision on near-SOI science will be made by the Cassini PSG and the Mariner Mark II Project.

At apoapsis of the initial orbit (about 50 days after SOI) a maneuver will be performed to raise the orbit periapsis from 1.3 to about 9 R_S, and to target the spacecraft to Titan. Final targeting maneuvers will be performed to adjust the Probe aim point, and the Probe will be released from the Orbiter about 22 days before Titan encounter. About 2 days after Probe separation, the Orbiter will perform a deflection maneuver to establish the proper Titan flyby conditions for Probe data relay and the start of the orbital tour.

5. Orbiter Mission. The Cassini orbital tour will begin immediately upon completion of the Probe mission, and last until four years after SOI. It will consist of about 60 orbits of Saturn, each with a period of approximately 32 days. The precise dimensions and orientations of these orbits will be dictated by the various science requirements, and will be achieved by Titan gravity-assist flybys and/or small propulsive maneuvers. The reliance on flybys of Titan for gravity assist means, effectively, that the Saturn Orbiter part of the Cassini mission has two primary targets, Saturn and Titan. During the course of the 4-year tour of the Saturnian system there will be opportunities for detailed study of both

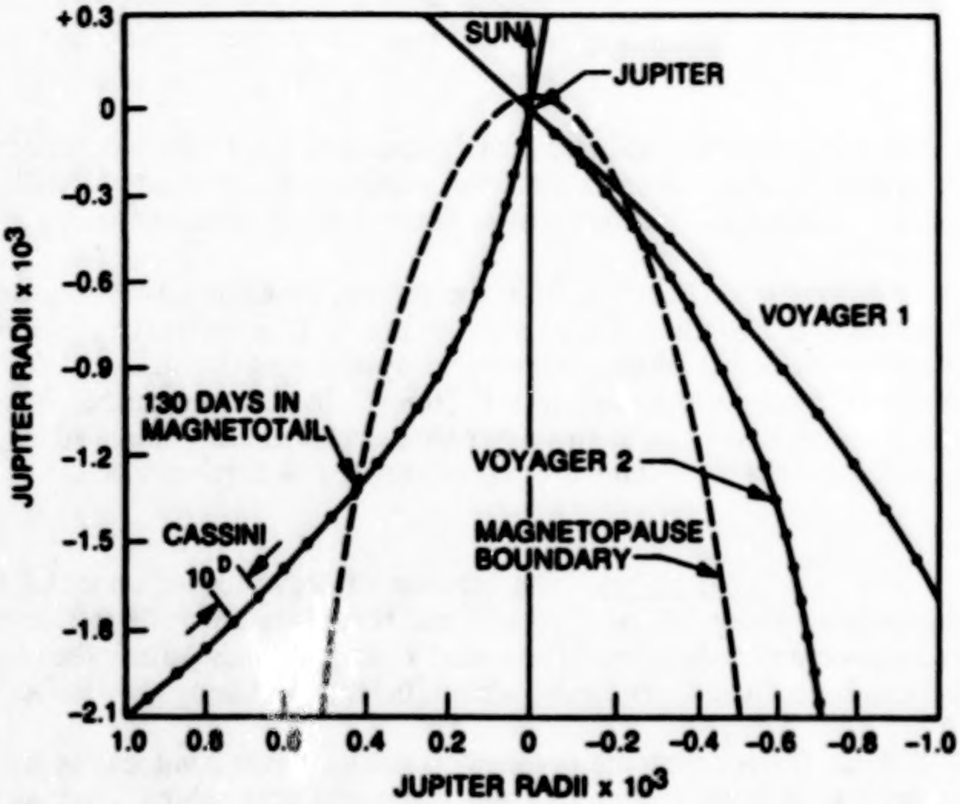

Figure 3. Jupiter Magnetotail Passages

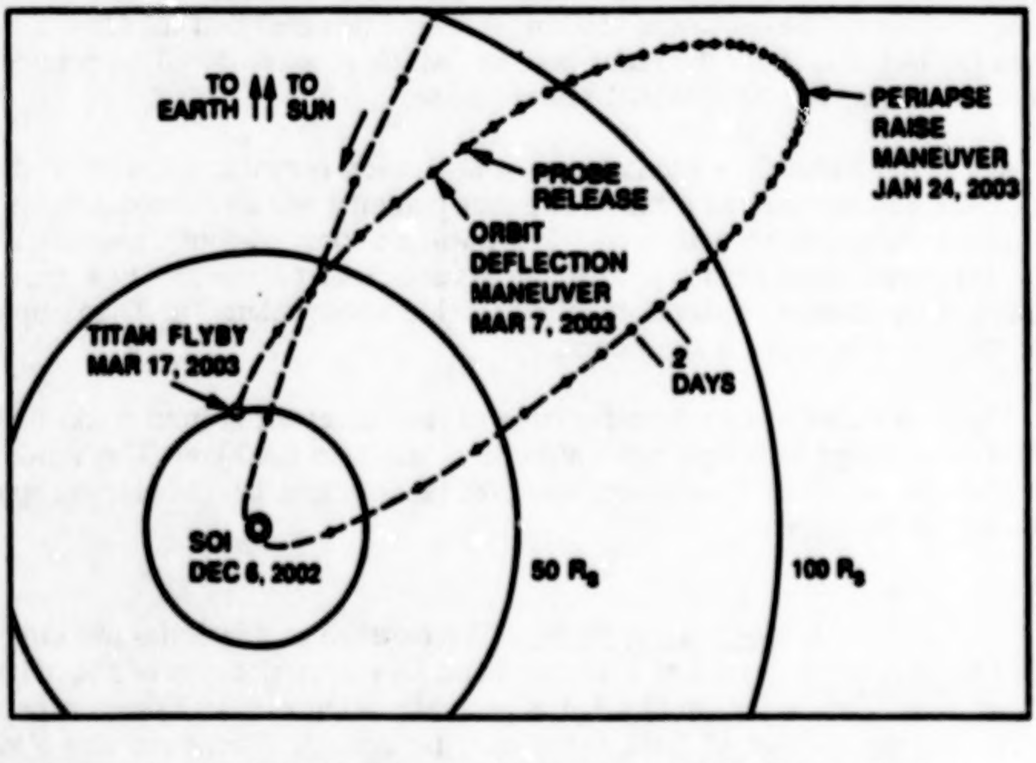

Figure 4. Cassini 1996 Baseline Trajectory - Initial Saturn Orbit

of these bodies, as well as the icy satellites, the rings, the magnetosphere, and their mutual interactions.

The nominal orbital tour will end with the spacecraft in a high-inclination orbit with a period of about 7.1 days. From a trajectory design standpoint, there could be many opportunities for additional Titan flybys after the end of the nominal tour.

Figure 5 shows selected orbits from the current baseline Cassini tour, designated 89-01. While this is the baseline orbital tour for planning purposes, the detailed strategy and tour design for the actual mission will be developed during the mission definition phase by the Cassini PSG and the Mariner Mark II Project. In addition, further analysis of the hazard to the spacecraft posed by Saturn ring particles may indicate the need for additional constraints on the orbital tour. This is discussed further in Section V.A.5.e.

a. Titan Flybys. The baseline strategy calls for an initial Titan flyby that occurs at a low altitude (about 1500 km) and that simultaneously reduces the spacecraft's orbital period and inclination. The initial Titan flyby must satisfy the requirements of the Probe's radio relay link geometry, while efficiently initiating the Orbiter's tour.

The 35 Titan flybys during the baseline orbital tour have a velocity of about 6 km/s at closest approach to Titan. Seven of these flybys will pass behind Titan as seen from Earth, resulting in Titan occultations of about 10-18 minutes duration. In the present tour design, these occultations occur fortuitously; no attempt has been made to optimize the flyby geometry to increase the number of occultations. Of the 35 Titan flybys, 32 occur at altitudes of 8000 km or less, and thus would be useful for the radar instrument. The lowest expected altitude for these flybys is 950 km. It should be noted that the Orbiter High Gain Antenna (HGA) is used for the radar function, which requires that it be pointed at Titan (rather than Earth) for the RADAR science passes.

While the Titan flyby geometry must be chosen primarily to produce the desired effect on the Saturn-centered orbit, future tour planning will also consider ways in which Titan flyby science can be optimized. There will be some tradeoffs required as a Titan flyby is perturbed away from the optimum gravity assist parameters to a geometry that maximizes flyby science. Spacecraft safety considerations related to Titan's upper atmosphere must also be taken into account.

Figure 6 shows a representative trace of the spacecraft ground tracks on a map of Titan for close flybys with a periapsis altitude of less than 8000 km. These ground tracks do not show the actual widths or locations of the radar swaths, but indicate the approximate distribution of coverage.

b. Icy Satellite Flybys. The baseline tour includes two targeted close flybys of Iapetus and one each of Enceladus and Dione, at altitudes of about 1000 km or less. Inclusion of close icy satellite flybys generally requires a significant expenditure of propellant, so the number of these flybys must be limited. There are also a total of 39 nontargeted satellite encounters at distances less than 100,000 km during the baseline

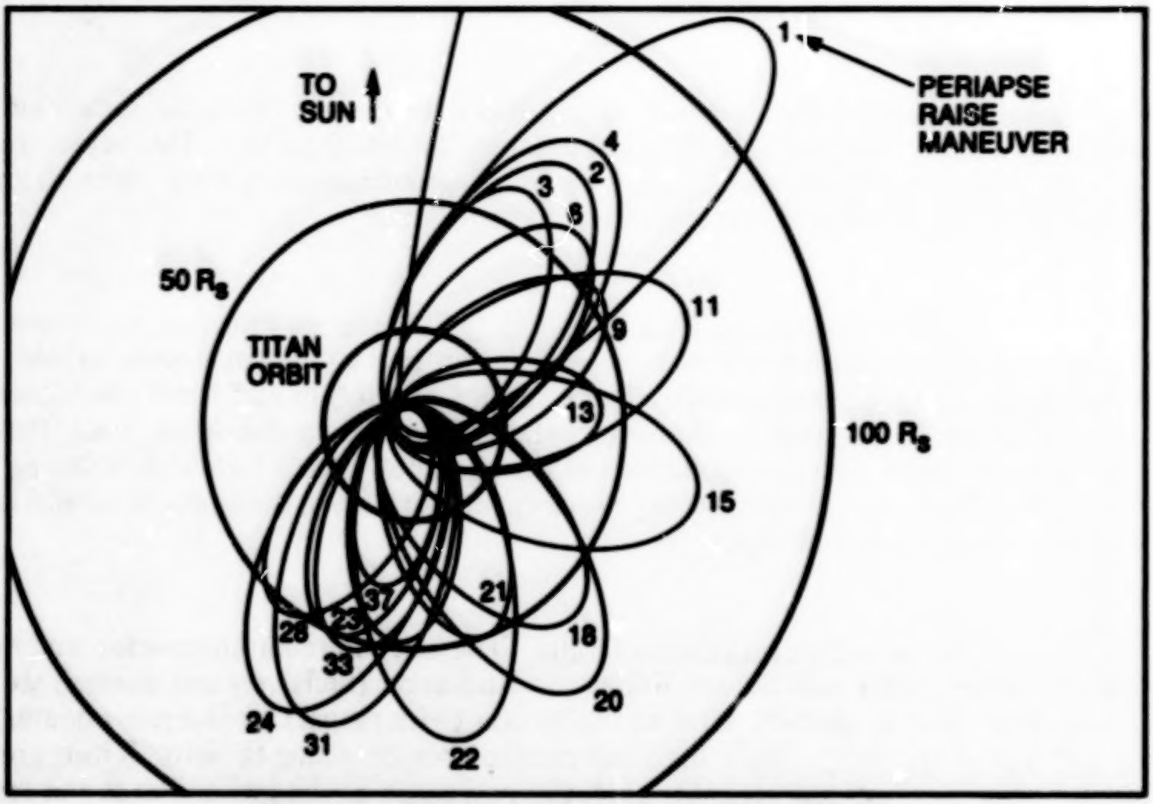

Figure 5. Representative Saturn Tour (89-01)

Figure 6. Ground Tracks of Titan Flybys (Altitudes Below 8000 km) During a Representative Saturn System Tour (89-01)

mission. All major Saturnian satellites are included in this set, with the exception of Phoebe which is encountered only during the Saturn approach phase. The velocities of the satellite flybys range from about 3 km/s for the targeted Iapetus flybys to over 20 km/s for flybys of Mimas and Enceladus near the end of the tour.

c. Saturn and Ring Occultations. There are four equatorial and 18 high-inclination passes behind the disk of Saturn, and five additional passes behind the rings during the current baseline tour. These result in both Sun and Earth occultations. No attempt has yet been made to find useful stellar occultations during the tour, though they undoubtedly exist. Saturn occultations will not generally occur fortuitously during the tour as do the Titan occultations, so any requirement for Saturn occultations would have a significant effect on tour design.

d. High Inclination Orbits. The science requirements for investigation of the Saturn polar and Saturn Kilometric Radiation (SKR) regions mean that the spacecraft must achieve an orbit with an inclination (with respect to Saturn's equator) of about 80° during the tour. Such high inclinations can be achieved using Titan gravity assists, but only if the orbital period is gradually decreased as the inclination is increased. An inclination of 80° can be reached if the spacecraft orbital period is reduced to about 7.1 days.

e. Ring Plane Crossings. There will be many crossings of Saturn's outer rings during the tour; these may provide useful science opportunities for dust and plasma experiments. Two crossings in the F-G ring gap at about 2.7 R_S will occur immediately before and after SOI, and crossings of this type occur again near the end of the tour. The majority of the crossings will be in the E-ring between about 4 and 7 R_S. It is possible that the spacecraft orientation will be constrained during ring plane crossings to minimize the possibility of damage due to particle impacts.

The baseline tour includes a number of near-equatorial Saturn orbits; for these very low-inclination orbits, the spacecraft will spend a significant amount of time traversing the E-ring, from its edge at about 9 R_S to orbit periapsis at 3-5 R_S, and back out again. These orbits will cross the orbits of the major E-ring satellites; recent modeling suggests that increased populations of potentially hazardous particles may exist near these orbits. If the presence of these hazards is confirmed, the near-equatorial orbits may have to be modified to avoid them. This would reduce the number of icy satellite encounters during the tour, and may result in the loss of several Titan flybys. In addition, coverage of the inner magnetosphere would be affected, as would the ability to reach the desired 80-degree inclination by the end of the tour.

Further details regarding this issue and the Orbiter baseline mission can be found in Volume III of the Proposal Information Package.

6. <u>End of Mission</u>. For purposes of this AO, the nominal mission will end in December 2006, four years after SOI. Depending on the remaining propellant and the condition of the spacecraft, an extended mission phase could be considered. If an extended mission phase is undertaken, it is NASA's intent to issue an open announcement inviting proposals from all who might wish to participate; new proposals will be required from investigators participating in the primary mission who wish to continue their previously selected investigations into the extended mission phase.

B. SPACECRAFT CAPABILITIES AND CONSTRAINTS

The Saturn Orbiter to be used for the Cassini mission will be the second spacecraft of the Mariner Mark II (MM II) series. The MM II spacecraft is specifically designed for high-quality science return from cometary, asteroidal, and planetary missions beyond the orbit of Mars. The combination of inheritance, common spacecraft modular components, and new technologies applied to spacecraft parts reduces overall mission costs. The spacecraft is designed to operate from 0.88 AU to 10 AU from the Sun, with a design life of 12 years.

Use of the MM II spacecraft imposes specific constraints on the mass, volume, power, and data return capabilities available to the science instrument payload. These capabilities and constraints are described in detail in Volume IV, Spacecraft Description, of the Proposal Information Package. Current design studies indicate that available resources for the Saturn Orbiter science payload will be:

Mass:	197 kg
Power:	213 watts at Saturn arrival (post SOI) 167 watts at End of Mission
Data:	Capability to record on two tape recorders, each with 1.8×10^9 bits storage and a bit error rate of 5×10^{-6}. Normal operation will allow one tape recorder to be used for recording while the other recorder plays back data to the downlink. The data rate is 200 kilobits per second (kbps) maximum on the multiplexed bus and 403 kbps maximum on the non-multiplexed bus.

Deep Space Network (DSN) coverage during the orbital tour will normally consist of two 70-meter station passes per day for the high-activity periods of each orbit (e.g., about 12 days out of each 32 day orbit), and one 34-meter station pass per day for the remainder of each orbit. Downlink data rates will vary between 31 and 84 kbps (1100 to 2890 megabits (Mb) data returned per pass) when the spacecraft is 8 AU from Earth, and between 31 and 55 kbps (690 to 1880 Mb data returned per pass) when the spacecraft is 10 AU from Earth, depending on the particular DSN 70-meter station being used.

The other features of the MM II Saturn Orbiter spacecraft are described below.

The MM II spacecraft will be three-axis stabilized, using a High Precision Scan Platform (HPSP)-mounted inertial reference unit and star tracker, a Sun sensor, a reaction wheel assembly, and thrusters. Instruments requiring fine pointing control can be located on the HPSP. Specifications for the allowable volume and inertia on the HPSP are included in Volume IV of the Proposal Information Package.

The Huygens Probe will be mounted on and deployed from the Orbiter spacecraft near the end of the initial Saturn orbit. The ESA-provided Probe Support Subsystem will be installed on the Orbiter spacecraft and will consist of the Probe relay antenna assembly, electronics, and the Probe spin-eject device.

High data rate communication with Earth will be via a 3.66 meter diameter Voyager-design High Gain Antenna (HGA), body-fixed and aligned with the Orbiter's -Z axis. An aft-facing (+Z axis) Low Gain Antenna (LGA) and a forward-facing (-Z axis) LGA will be used for two-way communication with the Earth when spacecraft pointing requirements preclude use of the HGA. Redundant 10.6 watt X-band solid state amplifiers and a new NASA X-band transponder will be used. The spacecraft transmitter frequency will be 8.415 GHz and the spacecraft receiver frequency will be 7.162 GHz. A 5.0 watt S-band transmitter may be provided for the Radio Science Subsystem (RSS). For further information, see RSS Facility Instrument, Section V.C.2.e.

The spacecraft provides only those antennas intended for telecommunications with the Earth and for the contemplated RADAR Facility Instrument. If a proposed instrument requires an additional antenna, it must be proposed as part of that instrument package and its cost must be included in the proposal.

Most electronics for the spacecraft engineering subsystems and some science electronics will be located in the slightly modified Voyager ten-bay toroidal bus.

Four deployable booms will be provided: the HPSP boom, turntable boom (for the turntable and ram-direction (RAM) platform), RTG boom for the Radioisotope Thermoelectric Generators, and the magnetometer boom. Specifications on instrument platform and spacecraft pointing accuracy are contained in Volume IV of the Proposal Information Package. If a proposed instrument requires an additional boom, it must be proposed as part of that instrument package and its cost must be included in the proposal.

A rotating platform (turntable) on the turntable boom (opposite the HPSP) will provide a greater than 2-pi steradian field of view for fields and particles instruments. The rotation rate will nominally be one revolution per minute while orbiting Saturn; three revolutions per minute will be possible for limited periods; and 0.1 revolution per minute is planned for much of the cruise to Saturn. Specifications on turntable capabilities are included in Volume IV of the Proposal Information Package.

The RAM platform will be available for Titan aeronomy instruments and can be preprogrammed to move through small angles, compensating for the changing Orbiter spacecraft attitude. Specifications on RAM platform capabilities are included in Volume IV of the Proposal Information Package.

A Propulsion Module Subsystem (PMS) will be obtained from the Federal Republic of Germany (FRG). The PMS will use a bipropellant (monomethylhydrazine [N_2H_3] and nitrogen tetroxide [N_2O_4]) for the main engine, and a monopropellant (hydrazine) for the reaction control system with eight identical thruster clusters. There will be two bipropellant tanks with total capacity of 3450 kg. Additional details of the PMS are included in Volume IV of the Proposal Information Package.

Thermal control of the spacecraft will be accomplished by combinations of electrical heaters, one-watt radioisotope heater units, louvers, thermal blankets, and paints.

Two nickel-cadmium batteries will provide energy storage for short science sequences and engineering power peaks which exceed the output of the two General Purpose Heat Source RTG's. Solid-state switches will be used in the power distribution unit, replacing traditional electromechanical relays and thereby eliminating fuses, providing soft turn-on and programmable current limiting, and enhancing fault protection.

The spacecraft will use programmable computers which control the uplink, downlink, subsystem intercommunication, and sequence execution functions, and provide command, telemetry, and system fault protection functions to all subsystems. A 35 Mb buffer memory will allow the data system to rate-match data input to the tape recorders and from the recorders to the downlink to optimize performance. All science instruments and engineering subsystems will use a project-supplied (at instrument expense; see Volume I of the Proposal Information Package) standard MIL-STD-1553B bus interface unit to communicate with the spacecraft Command and Data Subsystem.

Magnetic, electromagnetic, and electrostatic cleanliness of the Saturn Orbiter will be maintained and controlled. However, the presence of the RTG's and the radioisotope heater units will result in radioactivity on board the spacecraft. Specifications on spacecraft cleanliness and radiation are included in Volume X of the Proposal Information Package.

C. SATURN ORBITER STRAWMAN INSTRUMENT PAYLOAD

1. Introduction

During preliminary studies of the Cassini mission, the potential Saturn Orbiter instrumentation needed to satisfy the science objectives was closely examined to seek a proper balance between anticipated scientific results and mission costs. The result of these studies was the definition, by the Cassini JSWG, of a strawman payload (Table 1) that would be capable of satisfying the scientific objectives and which could also be accommodated on the MM II Saturn Orbiter.

Further discussion of these strawman instruments, including their expected scientific return, is included in the Cassini Phase A Report (SCI(88)5), Volume II of the Proposal Information Package. It should be understood that this strawman payload concept has been developed for planning purposes only. The actual payload will be determined from the competitive evaluation of proposals submitted in response to this AO. It may or may not include instruments in the strawman payload, and it may include entirely different instruments.

Table 1. Cassini Saturn Orbiter Strawman Payload

Instrument/Investigation	Main Scientific Objectives
Imaging Science Subsystem (ISS) (Potential Facility Instrument - see Section V.C.2)	Imaging of atmospheres, satellites, and rings.
UV Spectrometer/Imager	Saturn and Titan atmospheric composition, ionosphere remote sensing.
Visual and Infrared Mapping Spectrometer (VIMS) (Potential Facility Instrument - see Section V.C.2)	Compositional identification and mapping of icy satellites, rings, and cloud structure.
Composite IR Spectrometer	Atmospheric composition and vertical and horizontal distribution of constituents. Deep sounding of Saturn and Titan.
Microwave Spectrometer and Radiometer	Atmospheric abundance of CO, HCN, HC_3N, and surface properties of Titan. NH_3 abundance in Saturn.
Saturn Atmosphere Mapper	Atmospheric temperatures and thermal winds in the 1-5 bar zone; up-welling and down-welling.
High Speed Photometer	Stellar occultation measurements for atmosphere and ring science.
Titan Radar Mapper (RADAR) (Potential Facility Instrument - see Section V.C.2)	Imaging/Mapping/Altimetry of Titan surface. Subsurface sounding of Titan and icy satellites.
Radio Science Subsystem (RSS) (Spacecraft Radio Frequency Subsystem may be used as part of Radio Science Subsystem Facility Instrument - see Section V.C.2)	Titan and Saturn atmospheric structure profiles. Ring physical properties. Satellite masses and gravitational moments of solid bodies. Gravitational waves.
Dust Analyzer	Physical properties of dust particles.
Plasma/Radio Wave Spectrometer (Antennas to be provided by the PI)	Spectral frequency characteristics of magnetospheric and ionospheric emissions.

Table 1. (continued)

Plasma Spectrometer	Composition, charge-state and energy distribution of magnetospheric plasma; 3-D measurements
Magnetospheric Imaging Instrument (Combination of Hot Plasma Detector and Energetic Neutral Analyzer)	Composition, charge-state and energy distribution of energetic ions and electrons. Detection of fast neutral species. Remote imaging of magnetosphere.
Magnetometer	Magnetic field measurements.
Ion/Neutral Mass Spectrometer	Titan aeronomy and chemical composition of Saturn's magnetosphere.
Retarding Potential Analyzer and Langmuir Probe	Cold plasma measurements.

2. Facility Instruments

a. Background. In response to the strategy and recommendations developed by the SSEC, NASA's Solar System Exploration Division has established a program to define and develop certain instruments considered appropriate for a series of related future solar system missions. The purpose of this activity is to ensure a steady level of instrument development to meet the demands of future missions in a cost-effective manner, especially when there is a high degree of commonality between the requirements of successive missions. The intention is to use appropriate modifications of these instruments as Facility Instruments on future missions. Within this Planetary Instrument Definition and Development Program (PIDDP), Instrument Development Teams (IDT's) have been established to undertake the definition and development of several appropriate instruments.

Two such instruments, the Imaging Science Subsystem (ISS) and the Visual and Infrared Mapping Spectrometer (VIMS), are Facility Instruments on the CRAF mission and are being considered by NASA as candidate Facility Instruments for the Cassini Saturn Orbiter. In addition, the Titan Radar Mapper (RADAR) is a candidate Facility Instrument for the Saturn Orbiter. The spacecraft Radio Frequency Subsystem (RFS) will be provided by NASA; it may be operated as part of the Radio Science Subsystem (RSS) Facility Instrument. Unlike the ISS, VIMS, and RADAR, an IDT has not been involved in the development of the RSS. Brief descriptions of the ISS, VIMS, RADAR, and RSS are given below; for more details, see Volumes VI, VII, VIII, and IX of the Proposal Information Package.

Final decisions regarding the inclusion of the ISS, VIMS, and RADAR in the Saturn Orbiter payload and use of the RFS for radio science investigations as part of the RSS Facility Instrument have not yet been made. Such decisions will be made on the basis of proposals received in response to this AO.

In the event that the ISS, VIMS, or RADAR is selected for inclusion in the Saturn Orbiter payload, or the decision is made to operate the RFS as part of the RSS Facility Instrument, NASA will form a Flight Investigation Team for each instrument involved (ISS, VIMS, RADAR, or RSS). This AO invites proposals from individuals to be the Team Leader (TL) or a Team Member (TM) of such a team (see Section III.A.2). Selection of Team Leaders and Team Members for the Saturn Orbiter portion of the Cassini mission will be made on the basis of proposals received in response to this AO.

Proposers who wish to be Team Leaders or Team Members of Flight Investigation Teams for the ISS, VIMS, RADAR, or RSS should submit Facility Instrument Team Leader/Team Member proposals (See Sections III.A.2 and VI.B). Proposers for the ISS, VIMS, and RADAR Teams should propose on the basis of the baseline instrument descriptions given in Volumes VI, VII, and VIII of the Proposal Information Package. In the case of the RSS only, individuals proposing to be Team Leader or a Team Member may propose to use the planned baseline RSS (see Section V.C.2.e and Volume IX of the Proposal Information Package), or they may also propose modifications or additions to the RSS in order to enhance its science capabilities for the mission.

After tentative selection of investigations and formation of the appropriate Flight Investigation Teams, the Mariner Mark II Project, working in conjunction with the Flight Investigation Teams, will be responsible for the development of the flight versions of the Facility Instruments. The Flight Investigation Teams, through the instrument managers, will provide for the design, fabrication, calibration, and integration of the flight model of each selected Facility Instrument. The Flight Investigation Team will also be responsible for investigation design, observation planning, procedure and algorithm development for data reduction, science analysis and interpretation, publication of results, and data archiving.

The IDT's already formed will continue to function during the period of development of the Cassini mission, first to help the new Flight Investigation Teams in assuming their responsibilities, and then to undertake the definition and development of advanced versions of appropriate instruments for future missions.

Brief descriptions of the candidate Facility Instruments for the Saturn Orbiter are given below. More detailed information is contained in Volumes VI, VII, VIII, and IX of the Proposal Information Package.

b. Imaging Science Subsystem (ISS). The Saturn Orbiter ISS will be identical to the CRAF ISS, except for filters selected for the Cassini mission. The Saturn Orbiter imaging investigation must encompass a wide variety of targets (Saturn, Titan, rings, satellites, asteroids, Jupiter, and star fields) and a wide range of observing distances. Therefore, the ISS will use two separate cameras (Narrow Angle and Wide Angle) to provide two different scales of image resolution and coverage. However, to minimize mass,

power, and cost, the two cameras will share a common electronics module. The two cameras differ primarily in the design of the optics and spectral filters. Most other components (filter changing mechanism, shutter, detector head, and radiator) are the same for both cameras. A brief description of the ISS components and performance parameters is given below.

Both optical systems are protected by articulated dust covers. The covers will open and close on command, and are activated by redundant harmonic drive mechanisms.

The Narrow Angle Optics will be a 2000 mm f/10.5 Ritchey-Chretien telescope with added field correctors. The pixel size is 6 microradians and the field of view is 0.35 degrees. The Wide Angle Optics will be a 250 mm f/4 refractor designed to minimize size and complexity. The pixel size is 48 microradians and the field of view is 2.8 degrees.

Each camera will contain a selectable optical filter assembly consisting of two parallel rotating wheels which move the spectral filters in and out of the optical path. The Narrow Angle assembly will carry 22 filters and will have a wavelength range from 200 to 1100 nm. The Wide Angle assembly will carry 14 filters and will have a wavelength range from 350 to 1100 nm.

Each camera will contain a two-blade focal plane shutter of the design used on Voyager and Galileo. The shortest reliable exposure time will be about five milliseconds, with no limit on the longest time.

The detector head will contain the Charge Coupled Device (CCD) image detector and the drive circuits, analog signal chain circuits, and temperature control devices which must be co-located with it. The detector will be a front-side-illuminated silicon CCD. The format will be 1024 x 1024 with 12 micrometer pixels. A coating of lumogen will be used to extend the sensitivity into the near ultraviolet. In the spacecraft environment, the system (or read) noise is estimated to be 12 electrons per pixel, RMS. The saturation level (or full well) is estimated to be 60,000 electrons, so that the dynamic range of the CCD will be about 5000. Since the dynamic range of the detector will exceed the range of the analog-to-digital converter, two gain states will be provided.

The common electronics will consist of the digital signal chain, mechanism drivers, power supplies, and a microcomputer for command, timing, and logic. The digital signal chain will contain a square root processor and a factor-of-two rate controlled data compressor. In the basic operating mode, the frame time will be 20 seconds.

For further details on the ISS, see Volume VI of the Proposal Information Package.

c. <u>Visual and Infrared Mapping Spectrometer (VIMS)</u>. Scientific goals of the VIMS are to obtain compositional data on satellite surfaces, the asteroid, the rings, and to map cloud properties. The Cassini VIMS will be identical to the CRAF VIMS. The baseline design will include 320 contiguous spectral channels with ~11 nm sampling between 0.35 and 2.4 μm, and 22 nm sampling between 2.38 and 5.14 μm. The instantaneous field of view (IFOV) will be 0.5 mrad. Mapping will be accomplished by scanning

the IFOV cross-track and down-track with an internal scanning mirror. The scanner can produce a variable swath up to 64 pixels wide. The data volume downlinked will be reduced by selectively summing, averaging, and editing spatial or spectral pixels, and by data buffering. The VIMS will consist of four major assemblies: (1) the fore-optics, containing the scanning secondary mirror, (2) the grating spectrometer, (3) the passive radiative cooler and focal plane, and (4) the electronics package.

The foreoptics will be an f/3.5, all-reflective Cassegrain system with an aperture diameter of 23.3 cm and a focal length of 81.3 cm. The secondary mirror will be articulated in two axes by a torque motor servo system.

The spectrometer will be an all-reflective Cassegrain system insulated and cooled to 175 K by a passive radiative cooler. Dispersion will be accomplished by a conventionally ruled, quadruple-blazed diffraction grating. A quadruple-blaze arrangement will be required due to the wide spectral coverage of the spectrometer. The dispersed spectrum will be reimaged on the detector array by a flat-field, all reflective camera. The focal plane will be comprised of two parallel linear arrays of 320 elements utilizing silicon for the visible region and indium antimonide for the infrared region, cooled to 77 K by the passive radiative cooler. Analog signals from the focal plane will be digitized to 12 bits, corrected for gain and offset, truncated to the 8 or 10 most significant bits as determined by the scene brightness, summed and averaged spectrally and/or spatially, and then packetized for telemetry.

For further details on the VIMS, see Volume VII of the Proposal Information Package.

d. Titan Radar Mapper (RADAR). The primary purpose of the radar investigation is to determine the characteristics of the Titan surface, which is obscured by a dense, opaque atmosphere. In addition, RADAR may also be used for studying other targets, such as Saturn ring particles and icy satellites if the flyby distances are sufficiently small.

The baseline RADAR instrument will have five operational modes. A synthetic aperture radar (SAR) mode will be operated over limited areas for surface imaging at pixel resolutions between 300 and 600 m; a multibeam imaging (MBI) mode will be used to acquire surface images over a much wider swath, at pixel resolutions from 2 to 7 km. Topographic measurements will be obtained by a nadir-looking altimeter (ALT) mode, and subsurface depth measurements by a sounder (SOU) mode. The vertical resolution for both ALT and SOU is 30 m. The depth to which the SOU S-band signals can penetrate will depend on the dielectric property of Titan's surface medium. At an orbiter altitude of approximately 1200 km, and for a surface medium with loss tangent value of about $5x10^{-5}$, the S-band signals will penetrate approximately 1 km below the surface layer. In addition, RADAR will be equipped with a nadir-looking scatterometer (SCAT) mode to accommodate the potentially large variations in radar reflectivity at different parts of Titan's surface. In the present design, the sensitivity of SCAT is such that surfaces with normalized noise-equivalent backscatter coefficients as low as -47 dB can be detected. The nominal RADAR operation time will be 60 minutes (30 minutes before to 30 minutes after closest approach)

during each close Titan flyby. In this scenario, the MBI is expected to cover approximately 1.5% of Titan's surface on each flyby.

In the current RADAR design, SAR, MBI, ALT, and SCAT will operate at 13.8 gigaHertz (GHz) (Ku-band), while the SOU will operate at 2.2 GHz (S-band). The telecommunications antenna reflector will be utilized with additional feeds for RADAR operation. Two pairs of linear array feeds at 13.8 GHz, each consisting of three small subarrays, will be offset from the reflector's focal point to generate six side-looking antenna beams during SAR and MBI operations. Center feeds at 13.8 GHz and 2.2 GHz will be incorporated at the reflector's focal point to generate single nadir-looking beams during the ALT/SCAT and SOU operations, respectively.

More instrument details are provided in Volume VIII of the Proposal Information Package.

e. <u>Radio Science Subsystem (RSS)</u>. Investigations in the area of radio science will be supported through the spacecraft RFS and the associated Deep Space Network (DSN) ground receiving and data recording equipment. The Radio Science Subsystem (RSS) will consist of certain elements of the RFS (i.e., the transponder, power amplifiers, and antennas) and any hardware elements optionally added to the RFS, as part of the radio science budget, to enhance its performance for radio science purposes. A detailed description of the planned RSS is provided in Volume IX of the Proposal Information Package.

The baseline Mariner Mark II Radio Frequency Subsystem (RFS) will receive and transmit X-band signals and will support both one-way and two-way radio science measurements. The X-band uplink frequency will be in the range 7145-7190 megaHertz (MHz); the downlink frequency will be specified by selection of the uplink frequency and will be in the range 8400-8450 MHz. One-way measurements with the baseline RFS will use the transponder's auxiliary oscillator, which will have limited stability as a signal source.

It is planned that interfaces will be provided on the spacecraft transponder to accommodate an ultrastable oscillator (USO), an S-band exciter (SXTR), and an S-band power amplifier (SPA). This equipment is not required for spacecraft engineering purposes; however, addition of these or other such devices could increase the instrument's stability and flexibility. Unless these or other performance-enhancing devices are added, the spacecraft RFS will be the limiting element in determining performance of the RSS. <u>If potential radio science investigators propose investigations that require augmenting the spacecraft RFS with any hardware additions as options, they must also propose inclusion of the optional equipment. The devices will be added to the spacecraft only if proposed by potential investigators and subsequently selected</u>. Costs for the optional hardware elements listed above (USO, SXTR, and SPA) have been estimated by the JPL MM II Project Office and should <u>not</u> be included in the potential investigator's proposal; they will, however, if selected, be charged against the mission's science budget. Costs for any additional optional hardware elements <u>not</u> listed above have <u>not</u> been estimated by the Project Office and <u>should</u> be included (and separately identified) in the potential

investigator's proposal. <u>All such hardware costs will be included in the science budget only if the potential investigation requiring the hardware is selected</u>.

Individuals proposing modifications and/or additions to the RSS (unless they are proposing the USO, SXTR, or SPA) <u>must</u> include in their proposal: (1) a detailed estimate of costs for the modifications and/or additions, including such items as algorithm development and data reduction; (2) sufficiently detailed information about special ground equipment or ground procedures required by these modifications and/or additions so that their costs can be estimated; and (3) the completed instrument questionnaire for PI/Instrument proposals, which is provided in Volume I of the Proposal Information Package.

In the event that such modifications and/or additions to the RSS are selected and included in the mission's science budget, the Mariner Mark II Project will be responsible for integrating such modifications and/or additions and for ensuring their flightworthiness and compatibility with the Orbiter and payload.

D. APPROACHES TO REDUCING INSTRUMENT COSTS

The scientific objectives of the Cassini mission, listed in Section II, place highest priority on the exploration of the Saturn system. The firm overall limitation on Saturn Orbiter science costs within the CRAF/Cassini program will result in a constrained selection of investigations, especially among those which address other objectives. Prospective investigators are encouraged to seek innovative approaches to reducing instrument costs. For example, coordination among proposers to optimize the measurement goals of related investigations, and/or to share common hardware, may lead to useful cost savings.

<u>Another approach to cost savings, which is particularly encouraged, is to share instrument development costs through international collaboration</u>.

<u>Investigators are also encouraged to reduce costs either by proposing to fly existing or planned spare instruments from other missions or by building exact copies of previously developed instruments</u>.

Opportunities for achieving cost savings will also occur during the Investigation Accommodation Phase (see Sections III.D and VII.B). At that time the PI's of certain tentatively selected investigations may be asked to reduce their experiment costs by coordinating measurement goals with related investigations, by sharing instrument hardware, or by coordinating their investigations in other ways.

E. SPECIAL MISSION CONSTRAINTS

Certain constraints are mandated by NASA's commitment to cost efficiency in all of its Mariner Mark II missions. Others arise because the science instruments to be carried by the Saturn Orbiter will be used in investigations lasting over an extended period of time. These instruments will generate extensive and complementary data sets.

The cost constrained nature of the mission creates special conditions: the scientific payload will be limited by cost as well as by mass, power, volume, data rate, duty cycle, and other key resources. Also, the number of selected investigators for each investigation must be restricted. <u>This latter limitation will constrain the number of Co-Investigators, Facility Team Members, and Interdisciplinary Scientists that can be selected on the basis of this AO.</u>

It is especially important that individuals proposing to be PI's on flight instrument investigations adequately justify the number of Co-I's that they plan to include in their teams. Each Co-I must have a defined task or tasks of significant value. <u>Time phasing of Co-I involvement should be seriously considered in order to reduce overall personnel costs.</u>

Special requirements are also created by the long duration of the data-taking phase of the Cassini mission and the complementary character of the data sets that will be obtained by the Saturn Orbiter and Huygens Probe instruments. To meet these requirements, individuals submitting PI/Instrument proposals or Team Leader proposals must include a plan for:

- Maintenance of raw and reduced data sets during the mission and until final archiving of the data.

- Registration of reduced data sets, using agreed-upon standards, so that the reduced data can be shared among the various science teams and Interdisciplinary Scientists within the project.

- Systematic data archiving, release, and distribution of reduced data records periodically during the project and at the end of the mission.

More information about plans for data collection and management for the Saturn Orbiter portion of the Cassini mission is contained in Volume V (Mission Operations Description) and Volume XI (Science Management Plan Document) of the Proposal Information Package.

No policies for the data rights of investigators or groups of investigators are established by this AO. It is anticipated that such rights will exist, but the establishment of such rights, and of the policies governing them, will be done after selection of investigations and the formation of the Cassini PSG. All policies concerning data rights, data management, data archiving, and data release will be developed by the Program and Project Offices in conjunction with the Cassini PSG.

F. FLIGHT ENVIRONMENT

The planned Cassini mission requires that the instruments survive and remain operable in several distinct environments. Information on these flight environments is provided in Volume X (Spacecraft Environmental Design Requirements) of the Proposal Information Package.

G. MISSION OPERATIONS

The Mariner Mark II Mission Operations System (MOS) will be located at JPL in a dedicated Mission Support Area (MSA). The MM II MOS will consist of the personnel, equipment, and procedures necessary to conduct flight operations for both the CRAF and Cassini missions. The MOS will be developed prior to launch in order to support the development and validation of basic flight sequences and to support spacecraft-to-MOS compatibility tests. The MOS will support spacecraft system test and launch operations phases and will assume spacecraft control at spacecraft delivery to the Eastern Test Range.

The MM II MOS will perform the primary functions of spacecraft command and control, spacecraft data acquisition, science and engineering information processing, and data archiving and data management. These functions will be performed with the aid of a network of interconnected data processors that are connected as nodes on a local area network.

The MM II Project will provide one Science Operations and Planning Computer (SOPC) workstation and a communication link for each of the Orbiter science investigation teams and one for the Huygens Probe Operations Center. The SOPC will support the following mission related activities:

1. Delivery of advanced planning information from JPL to the investigator team.

2. Construction by the investigator, and transmission to JPL, of instrument-specific command requests.

3. Delivery of raw instrument data and ancillary spacecraft information from JPL to the investigator.

4. Communication of data to and from other investigators.

During mission operations, raw instrument data in "packet" form will be maintained at JPL in the Project data base and will be accessible by the investigators through their SOPC. Each investigator will be responsible for promptly checking and reporting the health of his or her instrument as data become available. Geometric information (spacecraft attitude and trajectory parameters) sufficient to reconstruct instrument pointing will also be available and accessible to the investigator through the SOPC. The reconstruction of these data to obtain locations, instrument pointing directions, etc., will be the investigator's responsibility using Project-provided software. The investigator will also be responsible for maintaining updated data records that are accessible via the SOPC or similar work station to support interdisciplinary science activities.

The investigator will participate in the identification and resolution of science sequence request conflicts. Planning tools and data will be provided by the Project to assist in this process.

Detailed mission planning for Saturn orbital operations will begin 15 months prior to Saturn Orbit Insertion. During orbital operations, spacecraft command sequences will enter the final design and implementation stage approximately 60 days prior to the actual start of sequence execution. A limited late-date update capability will exist.

Science observations performed by the Saturn Orbiter will be accomplished through the execution of stored onboard sequences. Cruise sequences will be of three months duration and Saturn orbit sequences will be of one orbit duration, typically 32 days. Stored sequences may be augmented by real time commands. All real time commands will be split into two categories: interactive and non-interactive. An interactive command will require mission director approval for uplink because spacecraft and ground resources must be expended in the ground generation and spacecraft execution of that command. Noninteractive commands are those which do not affect spacecraft resources and they will, therefore, be uplinked routinely.

Details regarding the investigator's responsibilities are given in Section V.I below (Data Records Requirements and Data Analysis) and in Volumes V and XI of the Proposal Information Package.

Definition of the SOPC is the responsibility of the Jet Propulsion Laboratory's Space Flight Operations Center (SFOC), with oversight by the MM II Project. It is intended that, after selection, the investigators will participate, through the Cassini PSG, in determining the final configuration of the SOPC and in the development of common software and data formats to assist the investigators in meeting their responsibilities for data management and archiving. The MM II Project will support development of the SOPC and common software to the maximum extent possible. The details of software implementation will be established by discussions between Project management and the Cassini PSG. All investigators must be prepared to use the SOPC during prelaunch spacecraft testing as well as during mission operations, and the investigators will be expected to support testing of the SOPC prior to launch.

For the purpose of providing a common basis for the review of proposals, proposers need not consider costs associated with the development of the work stations and the common software and data formats. (The SOPC work station environment is described in Volume V of the Proposal Information Package.) However, they should provide the best possible estimate of all costs for data management requirements (hardware and software) that are unique to their particular investigation and which clearly cannot be met by the SOPC alone.

H. PROGRAM MANAGEMENT

The Solar System Exploration Division of the NASA Office of Space Science and Applications has program management responsibility for the Cassini mission. Project management responsibility has been assigned to the Jet Propulsion Laboratory (JPL) in Pasadena, California.

The design, development, and implementation of the Cassini mission will involve the direct interaction of Program and Project Management and the Cassini PSG (see Section III.D).

I. DATA RECORDS REQUIREMENTS AND DATA ANALYSIS

Many of the scientific objectives of the Cassini mission can be realized only by the detailed analysis of simultaneous, complementary data sets obtained from multiple instruments. While some of these analyses will be accomplished during the mission itself, others will require extended study during a data analysis phase that will follow the mission.

To make shared analyses possible, both during and after the mission, the Project will require that raw data, calibration records, and processed data be maintained in an updated/upgraded form throughout the period of investigation. Specifically, Principal Investigators and Team Leaders must plan to:

- Maintain a continually updated/upgraded record of the "best version" of the data until significant changes in data calibration no longer occur.
- Adopt a standard format, agreed on by the Cassini PSG, for the "best version" of the data that will make the data easily accessible through the established work stations.
- Make updated/upgraded data records available to other investigators during the mission for shared analysis at times and to an extent determined by the Cassini PSG or by mutual agreement among investigators.
- Prepare a comprehensive set of data records, supported by appropriate documentation, for deposition in a designated archive at a time and in a format that will be agreed upon, and which is consistent with National Space Science Data Center and Planetary Data System standards. (See Volume XI, Science Management Plan Document, of the Proposal Information Package.)

To establish a common basis for the evaluation of proposals, the data analysis period used for budgeting purposes should be compatible with the Saturn Orbiter baseline mission schedule (see Section V.A.) and should not extend beyond a date one year after the Project delivers the last Supplementary Data File (SDF). For the Saturn Orbiter baseline mission, delivery of the last SDF is expected by the end of the year 2006 so that proposed analysis must not extend beyond December 31, 2007. It is anticipated that subsequent studies of Cassini data will be supported through competitive Data Analysis programs open to the entire scientific community.

VI. PROPOSAL SUBMISSION INFORMATION

This AO invites proposals from both United States and non-U.S. scientists for all the types of investigations described. Non-U.S. investigators are invited to propose as Principal Investigators, as Co-Investigators, as Team Leaders, as Team Members, or as Interdisciplinary Scientists. In accordance with NASA policy, all investigations by non-U.S. participants will be conducted without any exchange of funds.

In order to provide a firm basis for the comparison of proposals received in response to this AO, the Saturn Orbiter Baseline Mission described in Section V.A above and Volume III of the Proposal Information Package, the Facility Instrument Descriptions (see Section V.C.2 and Volumes VI, VII, VIII, and IX of the Proposal Information Package), the Science Management Plan Document (Volume XI of the Proposal Information Package), and the Spacecraft Description (Volume IV of the Proposal Information Package) should be used for proposal preparation. Safety considerations for science instruments are addressed in Volume XII (Policies and Requirements for Science Investigations) of the Proposal Information Package.

Concepts for minor modifications and/or additions to the Saturn Orbiter which enhance scientific return may be included in the proposals. However, such proposed modifications must be clearly marked as such, and any costs required for necessary modifications to the baseline spacecraft will be attributed to the investigation in question.

A. PREPROPOSAL ACTIVITIES

1. Notice of Intent

A written Notice of Intent to propose should be submitted by all prospective proposers and should arrive at NASA Headquarters on or before October 26, 1989. This Notice must be typewritten in English and should be addressed to:

Mr. Henry C. Brinton
Program Scientist, CRAF/Cassini
Code EPM-20 (Ref. AO No. OSSA-1-89)
NASA Headquarters
Washington, DC 20546
U.S.A.

Telephone Number: (202) 453-1597
FTS 453-1597
Telex Number: 89530 NASA WSH

Individuals responding to this AO from non-U.S. institutions and U.S. individuals whose investigation teams include individuals at non-U.S. institutions should send their Notice of Intent to the same address, but should also send a copy to:

International Relations Division
Code XID (Ref. AO No. CSSA-1-89)
NASA Headquarters
Washington, DC 20546
U.S.A.

Telephone Number: (202) 453-8452
Telex Number: 89530 NASA WSH

In cases where investigators from non-U.S. institutions are to participate as Co-I's in a proposal from a U.S. institution, the names of all potential non-U.S. participants should be included in any Notice of Intent submitted by U.S. proposers, even if the details of their participation cannot be formalized by the deadline for receipt of the Notice of Intent. Similarly, proposers from non-U.S. institutions who plan to include Co-I's from U.S. institutions in their proposals should identify such individuals and their institutions in the Notice of Intent.

The Notice of Intent should briefly describe the objectives of the proposed investigation. A brief description of any proposed instrumentation should be included if it is essential to the investigation. Proposers should include their names, addresses, telephone numbers, telex numbers, and the names and addresses of all Co-Investigators as well as their sponsoring organizations.

Individuals planning to attend either of the Preproposal Briefings (see below, Section VI.A.3) should include in their Notice of Intent the number of individuals attending, and at which location.

All material provided to NASA through the Notice of Intent is for information only and is not binding on the signatories. Additional information may be obtained from the CRAF/Cassini Program Scientist at the address above.

2. Proposal Information Package

A Proposal Information Package will be sent to all prospective proposers upon receipt of their Notice of Intent and to others upon receipt of a written request. The Proposal Information Package, which is intended to provide background information and specific details for the preparation of a formal proposal, contains the documents listed in Table 2.

Table 2. Proposal Information Package

Volume I	Proposal Preparation Guidelines
Volume II	Cassini Phase A Report (SCI(88)5) plus Addendum
Volume III	Mission Description
Volume IV	Spacecraft Description
Volume V	Mission Operations Description
Volume VI	Imaging Science Subsystem Description
Volume VII	Visual and Infrared Mapping Spectrometer Subsystem Description
Volume VIII	Titan Radar Mapper Description
Volume IX	Radio Science Subsystem Description
Volume X	Spacecraft Environmental Design Requirements
Volume XI	Science Management Plan Document
Volume XII	Policies and Requirements for Science Investigations
Volume XIII	Physical Models

Volumes I, X, XI, and XII of the Proposal Information Package are intended to provide requirements for prospective proposers in the preparation of proposals. The remaining documents provide information to aid in proposal preparation. In case of a conflict between requirements outlined in this AO and those in the Proposal Information Package, the provisions of this AO and its Appendices take precedence.

3. Preproposal Briefings

Preproposal Briefings, intended to be identical, will be held on November 9, 1989, at ESTEC, Noordwijk, The Netherlands, and on November 15, 1989, at the California Institute of Technology in Pasadena, CA. The purposes of these briefings will be to present details of both the Saturn Orbiter and the Huygens Probe portions of the Cassini mission and to respond to any questions that potential proposers may have. To ensure that such questions are fully answered, individuals who plan to attend either briefing are invited to submit their questions in writing, to be received at least seven days prior to the first briefing. Questions regarding the Saturn Orbiter should be sent to:

Mariner Mark II Project Office
(Cassini Preproposal Briefing)
Mail Stop 171-247
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109

Questions regarding the Huygens Probe should be sent to:

Huygens Project Group
c/o Future Projects Group
ESTEC
Postbus 299
2200 AG Noordwijk
The Netherlands

Potential proposers should state in their Notice of Intent whether or not they plan to attend a Preproposal Briefing and should indicate the number of colleagues associated with their proposal who will also attend and at which location.

Further details relating to these meetings will be sent to individuals who respond with a Notice of Intent or who request this information in writing from the CRAF/Cassini Program Scientist (see address above, Section VI.A.1).

B. FORMAT OF PROPOSALS

1. General Proposal Format

A uniform proposal format will be required from all proposers in order to aid in proposal evaluation and to facilitate comparative analysis. This format, and the required contents, are summarized below. Please note that the three types of proposals invited by this AO (PI/Instrument, Facility Instrument Team Leader/Team Member, and Interdisciplinary Scientist) have different content requirements and length limitations.

General information and general proposal requirements are provided as Appendices A and B to this AO. Specific procedures and details for each of the three types of proposals are described in Volume I (Proposal Preparation Guidelines) of the Proposal Information Package. Because three different types of proposals are invited by this AO, each of which requires different information, prospective proposers should carefully examine, and should prepare their proposals in accordance with, the detailed information given in Volume I.

Each proposal should be submitted in two (2) separately-bound volumes: Volume 1, Investigation and Technical Plan; and Volume 2, Management and Cost Plan. All documents must be typewritten in English and must be clearly legible. At least one copy of each document should be clear black print on white paper and of a quality suitable for reproduction. Submission of proposal material by facsimile (FAX), electronic media, video tape, floppy disk, etc., is not acceptable.

2. Investigation and Technical Plan (Volume 1)

Volume 1 should consist of the main body of the proposal and any optional appendices. The volume should provide a clear statement of the proposed investigation and how

it will address the scientific objectives of the Saturn Orbiter portion of the Cassini mission. The proposal should contain enough background information to be meaningful to a reviewer who is generally familiar with the field, although not necessarily a specialist.

The description of any proposed instrumentation must provide adequate technical information to permit evaluation. In addition, it must specifically address those spacecraft resources, configurations, or special requirements necessary for successful implementation of the proposed investigation. (Volume I of the Proposal Information Package contains added details.) This information should be given in sufficient detail to permit an evaluation of both the concept and the practical feasibility of the investigation. If appropriate, the proposal should describe the heritage of any proposed instrumentation, how the investigation is related to other proposed investigations, and the specific approach being taken to coordinate measurement goals and/or to share instrument hardware (see Section V.D). The proposal should also describe any recognized need for supporting laboratory research or ground-based, airborne, or other activities required to support development of the instrument and its operation during the mission.

The proposal should also contain the best possible description of the proposer's plans for data processing, management, and archiving, including the use of the remote work stations (see Section V.G). Many of the details of these procedures are not established at this time, but the proposal should include as much information as possible concerning the investigator's plans, requirements, and costs, especially those for unique data management requirements (hardware and software) that cannot be accommodated with the work stations.

The title page of Volume 1, for all types of proposals, must state the title(s), names(s), address(es), affiliation(s), and the telephone number(s) of the Principal Investigator, Co-Investigators, Team Leader, Team Member, or Interdisciplinary Scientist, as appropriate. The title page must also contain the authorizing signatures of appropriate officials of participating organizations. Such organizations may include industrial contractors who are part of the proposed team. In the Preface to Volume 1 the proposer must also include the following two pages: (1) a separate abstract, one page or less in length, describing the proposed investigation; (2) a separate table, one page or less in length, listing the major instrument parameters or specifications of the investigation, where appropriate. The title page and the two additional pages are not included in the page limits specified below. In complying with page limits, no page should contain more than 50 lines of text, and the type size should not be smaller than 12 characters per inch.

Details on length and other matters are given below for the three types of proposals. Regardless of proposal type, for all proposals, appendices are limited to a total of ten (10) single-spaced, typewritten pages, without reduction.

a. PI/Instrument Proposals. For proposals submitted by a prospective Principal Investigator, the main body of Volume 1 is limited to a maximum of forty (40) single-spaced, typewritten pages, without reduction, including illustrations, and may contain no more than four (4) foldout pages. In these proposals, the roles and responsibilities of the PI and of each Co-Investigator must be described, along with a time-phasing of their activities. Because the number of participants will be limited, each participant must have

an identified specific function which makes a demonstrable contribution to the development and/or implementation of the investigation. A condensed description of all prospective participants' relevant background, experience, and selected publications (if appropriate) should be provided in the body of the proposal.

b. Facility Instrument Team Leader/Team Member Proposals (ISS, VIMS, RADAR, and RSS Teams). For Team Leader proposals, the main body of the proposal is limited to a maximum of thirty (30) single-spaced, typewritten pages, without reduction, including illustrations. For Team Member proposals, the main body is limited to a maximum of ten (10) single-spaced, typewritten pages, without reduction, including illustrations. Team Leader or Team Member proposals involving modifications or additions to the RFS (see Section V.C.2) are limited to a maximum of thirty (30) single-spaced, typewritten pages, without reduction, including illustrations.

Proposals for Team Leader or Team Member on investigations using the ISS, VIMS, RADAR, or RSS Facility Instruments must be submitted by individuals only. Proposals by groups of investigators will not be considered. Proposers may identify, and may request support for, specific individuals or support staff whom they consider essential to the conduct of their investigation, but none of these individuals will be eligible for team membership without having submitted an individual proposal.

A proposer who wishes to be considered for Team Leader must provide documentation in the body of the proposal which supports the request. Team Leader proposals must also contain a generic or conceptual plan that addresses optimum team size and essential talents required for the team to meet its responsibilities. Individuals proposing to be Team Leader will also be considered for Team Member in the event that they are not selected to be Team Leader; if they do not wish to be so considered, they should so state in their proposal. Proposals for participation as a Team Member should, in addition to the scientific investigation proposed, provide information as to specific talents or technical capabilities that the candidate member would bring to the team.

Team Leader and Team Member proposals for the RSS involving modifications or additions to the spacecraft RFS (see Section V.C.2) must also justify the proposed modifications and/or additions in terms of their potential contributions and cost impact to the Cassini mission. Such proposals must also include the completed instrument questionnaire for PI/Instrument proposals, which is provided in Volume I of the Proposal Information Package.

c. Interdisciplinary Scientist Proposals. Proposals for Interdisciplinary Scientist are limited to a maximum of fifteen (15) single-spaced, typewritten pages, without reduction, including illustrations. These proposals must be submitted by individuals. Proposals from teams or groups of investigators will not be considered. However, individual proposers may identify, and request support for, appropriate support personnel in their proposal.

3. Management and Cost Plan (Volume 2)

This volume does not have page limitations.

a. PI/Instrument Proposals. For these proposals, Volume 2 should include a list of the key participants in the proposed investigations, together with brief statements of the backgrounds and areas of competence of each participant. Volume 2 should also include a detailed discussion of the specific roles that each of the participants and their institutions intend to play in the investigation. This discussion should include a statement of the portion of time which each participant expects to devote to the investigation and of the institutional resources on which each can draw.

Unwarranted management complexity is discouraged; therefore, proposals which involve more than five Co-Investigators and/or more than three participating organizations should specifically address the management issues involved in extensive collaboration.

Volume 2 must also provide a detailed estimate of the total cost of the investigation and cost spread per government fiscal year, along with sufficient technical information on which to judge the reliability of the figures. The assumptions on which the estimate is based should be stated, particularly with regard to Government-furnished equipment and services. Details on Cost Proposal Certifications are provided in Appendix A (General Instructions and Provisions) to this AO.

b. Facility Instrument Team Leader Proposals. For these proposals, Volume 2 should include a Management and Cost Plan based on the candidate Team Leader's best estimate of an optimum team size and the anticipated activity level of each of the members. No consideration need be given to the cost of building the Facility Instrument, but the Management and Cost Plan should reflect such activities as investigation design, instrument calibration requirements, observation planning, algorithm development, data reduction, and data archiving. Individuals proposing as Team Leader for the RSS must also include specific costs associated with any proposed modifications and/or additions to the spacecraft RFS (hardware, special ground equipment, and/or operations, etc.). See Section V.C.2.e for specific requirements.

Because Team Leader and Team Member proposals will be submitted separately, it will be difficult for prospective Team Leaders to develop a firm estimate of costs for the actual team that will be selected. For the purposes of proposal evaluation, Team Leader proposals should contain the best possible estimate of costs, based on the proposer's consideration of the number and type of Team Members needed and the level of activity required to carry out team responsibilities. More detailed estimates of the actual cost involved will be developed after selection of the Team Leader and Team Members for each team.

c. Facility Instrument Team Member and Interdisciplinary Scientist Proposals. Cost and Management Plans for these proposals may be simplified, within the guidelines of Appendix B, to the minimum length needed to permit evaluation. It is

expected that the bulk of costs for these proposals will be related to manpower (e.g., salary and travel for the Investigator and essential support personnel) and to data processing requirements. Individuals proposing as a Team Member for the RSS must also include specific costs associated with any proposed additions and/or modifications to the spacecraft RFS (hardware, special ground equipment and/or operations, etc.). See Section V.C.2.e for specific requirements.

4. Certification

All proposals must be signed by an institutional official authorized to certify institutional support and sponsorship of the investigation, as well as concurrence in the management and financial parts of the proposal.

5. Quantity

All proposers must provide thirty (30) copies of the Investigation and Technical Plan (Volume 1) and fifteen (15) copies of the Management Plan (Volume 2) to NASA. In addition, all proposers requesting NASA financial support, including U.S. Co-Investigators on non-U.S. proposals, must submit fifteen (15) copies of the Cost Plan (also bound in Volume 2) to NASA.

6. Submittal Address

Proposals must be mailed to the same NASA address as that for the Notice of Intent (see Section VI.A.1).

7. Deadline

Proposals must arrive at NASA Headquarters on or before February 8, 1990, at 4:30 PM Eastern Standard Time.

8. Notification

NASA will notify the proposers in writing that their proposals have been received. Each proposer should include a self-addressed envelope with the proposal for this purpose. Proposers not receiving this confirmation within two weeks after transmittal of their proposals to NASA should contact the CRAF/Cassini Program Scientist at the address in Section VI.A.1.

C. PROPOSALS FROM NON-U.S. INSTITUTIONS

Proposals from individuals outside the United States should be submitted in English and in the same format as U.S. proposals. Proposers from non-U.S. institutions are not required to submit a Cost Plan unless individuals seeking NASA support are involved in the proposal (see below); they must, however, submit a Management Plan. Proposers from non-U.S. institutions must have their proposals reviewed and endorsed by the appropriate sponsoring government agency. The endorsed copy of the proposal should be sent to the NASA International Relations Division (for address, see Section VI.A.1) and should arrive before the deadline for receipt of proposals.

The additional required copies of the proposal should be sent directly to the CRAF/Cassini Program Scientist (for address, see Section VI.A.1) and should arrive before the deadline for receipt of proposals. Sponsoring agencies may, in exceptional circumstances, forward advance copies of unendorsed proposals directly to the CRAF/Cassini Program Scientist if review and endorsement are not possible before the specified deadline. In such cases, NASA should be advised when endorsement can be expected.

In cases where the participation of a U.S. individual is included in a proposal submitted by a non-U.S. individual, and where it is requested that such participation be supported by NASA, a Management and Cost Plan covering such participation must be submitted to NASA as part of the proposal. This Management and Cost Plan must be signed by the U.S. individual and certified by the U.S. individual's institution. Such costs will be considered in the review and evaluation of proposals submitted by non-U.S. individuals.

Individuals at non-U.S. institutions who plan to participate on a U.S. proposal must have such participation reviewed and endorsed by their appropriate governmental agency before proposals involving such participation can be selected for the Saturn Orbiter portion of the Cassini mission. Evidence of such review and endorsement must be provided at the time that the proposal is submitted or as soon as possible thereafter. Formal arrangements for such participation will be made by NASA's International Relations Division with the non-U.S. sponsoring agency after selection of the proposed investigation.

All other correspondence from proposers at non-U.S. institutions and their sponsoring organizations should be sent to NASA's International Relations Division (for address, see Section VI.A.1).

All proposals from non-U.S. institutions will compete on an equal basis with U.S.-originated proposals, and go through the same review, evaluation, selection, and confirmation process. For those non-U.S. proposals selected, NASA will arrange with the sponsoring agencies for participation on a cooperative (no exchange of funds) basis, in which NASA and the sponsoring agencies will each bear the cost of discharging its separate responsibilities, including travel and subsistence for its own personnel.

VII. PROPOSAL EVALUATION CRITERIA, SELECTION, AND IMPLEMENTATION

A. EVALUATION CRITERIA

The fundamental aim of the investigation acquisition process is to identify scientific ideas and unique instrumental, theoretical, and analytical capabilities which best suit the overall scientific and cost objectives of the Saturn Orbiter portion of the Cassini mission, as described in this AO. Accordingly, the following criteria, listed in order of descending importance, will be used in evaluating all proposals submitted in response to this AO:

1. The scientific and technological merit of the proposed investigation and its relevance to this specific opportunity and to the established mission plans and objectives.

2. Total cost and management considerations. Total cost will be considered to include not only that proposed for the instrument development (for PI/Instrument proposals) and for data analysis, but also the impact of the instrument and the investigation on spacecraft and mission operation costs. Due to the program's strict financial constraints, any proposed instrument options that would enhance scientific return but increase cost should be clearly identified and costed so that evaluation and selection decisions can be made. Management aspects include demonstrated capability to adhere to sound business practices.

3. For proposals involving provision of an instrument, the adequacy of the proposed instrument for the proposed investigation, with particular regard to the instrument's ability to supply the data needed for the investigation within the Mariner Mark II spacecraft constraints such as mass, volume, power, available data storage and transmission rates, and sequencing. Relationships of proposed instrumentation to developed techniques, to previously flown spacecraft instruments, or to existing hardware will be factors specifically considered in determining adequacy.

4. The competence and relevant experience of the proposer and any proposed investigative team as an indication of their ability to carry the investigation to a successful conclusion.

5. The technical and cost risk (uncertainty) associated with the investigation.

6. The reputation and interest of the proposer's institution, as measured by the willingness of the institution to provide the necessary support (logistics, facilities, etc.) to ensure that the investigation can be completed satisfactorily.

NASA may desire to select only a portion of the proposer's investigation and may also desire the proposer's participation with other investigators in a joint investigation. In

this case, the proposer will be given the opportunity to accept or decline such partial acceptance and/or participation with other investigators.

B. EVALUATION AND SELECTION PROCEDURES

Proposals received in response to this AO will be evaluated in accordance with the provisions of NASA Handbook NHB 8030.6B (Guidelines for Acquisition of Investigations). All proposals will be subjected to a preliminary screening by the NASA Program Office to determine their suitability and responsiveness to the AO. Proposals which are not responsive to the intent of the AO will be handled as correspondence. Those proposals which are responsive to the AO will then be subjected to a preliminary technical, management, and cost assessment.

For PI/Instrument investigations, NASA will make use of both the investigator's proposal and a technical and cost evaluation of the proposal provided by the Mariner Mark II Project Office. This evaluation will include assessment of the cost impact on the Project of accommodating the instrument in the Saturn Orbiter payload; instruments which exceed the orbiter capabilities will be charged with the cost of any required spacecraft modifications.

Following these preliminary actions, the scientific and technical aspects of each proposal will be assessed by panels composed of individuals from the United States (2/3) and from Europe (1/3) who are scientific and technical peers of the proposers. A contracting organization will be selected by NASA to provide assistance in the peer panel review process. The purpose of this peer evaluation will be to determine the scientific and technical merit of each proposal, expressed in terms of its strengths and weaknesses. Results of the earlier technical and cost evaluation will be available to these reviewers.

After these evaluations, an ad hoc subcommittee of the NASA Space Science and Applications Steering Committee (SSASC) will consider the proposal evaluations, together with additional information regarding engineering, management, cost, and safety aspects. This subcommittee will then categorize the proposals according to the following definitions:

<u>Category I</u>: Well-conceived and scientifically and technically sound investigations pertinent to the goals of the program and the Announcement's objectives and offered by a competent investigator from an institution capable of supplying the necessary support to ensure that any essential flight hardware or other support can be delivered on time and within budget and that the data can be properly reduced, analyzed, interpreted, and published in a reasonable time.

<u>Category II</u>: Well-conceived and scientifically and technically sound investigations which are recommended for acceptance, but at a lower priority than Category I.

<u>Category III</u>: Scientifically and technically sound investigations which require further development. (Only applicable to proposals which include development of flight hardware.)

Category IV: Proposed investigations which are recommended for rejection for this particular opportunity, regardless of the reason.

In parallel with the NASA evaluation process for Saturn Orbiter proposals, ESA will evaluate the Huygens Probe proposals received in response to the ESA AO. The Probe peer review panels will be composed of individuals from Europe (2/3) and the United States (1/3).

NASA and ESA will each adhere to its own procedures in selecting investigations for the Saturn Orbiter and Huygens Probe, respectively. These procedures and the selections themselves, however, will be closely coordinated and will involve exchange of observers at key points throughout both processes.

For the Saturn Orbiter, following the evaluations described above, and in coordination with ESA, the NASA Program Office (Solar System Exploration Division) will develop a payload recommendation. This recommendation, and all peer review and categorization materials on all the proposals, will be submitted to the SSASC for review. Selections for the Investigation Accommodation Phase will be made by the Associate Administrator for Space Science and Applications based on the final recommendations of that Committee.

An Instrument Definition Phase will not be funded for the Saturn Orbiter portion of the Cassini mission because it is expected that the instruments proposed will be well understood and will have significant design and hardware inheritance from previous spacecraft experiments. Rather, after tentative selection of the investigations, the Project will enter an Investigation Accommodation Phase (see Section III.D) which will last about thirteen months. During this period, all tentatively selected investigations will be evaluated for cost, compatibility with the Mariner Mark II spacecraft, compatibility with other mission constraints, and (for IDS investigations) compatibility with the final selected payload.

Support provided to instrument-related investigators (PI's, TL's, and TM's) during the Investigation Accommodation Phase will be primarily for achieving an understanding of the instrument modifications required to match the configuration and constraints of the Mariner Mark II spacecraft and for developing a detailed plan for building, testing, and calibrating the flight instruments themselves. In addition, proposers of certain tentatively selected investigations may be asked during this phase to coordinate the design and development of their instruments with other related instruments in ways which would reduce overall cost (see Section V.D). Support for IDS investigators during this period will be to develop a more detailed understanding of the requirements for their investigations and to permit a more detailed assessment of the compatibility of the investigation with the tentatively selected payload. Project funds will not be utilized to support extensive activities involving the development of new technologies.

At the end of the Investigation Accommodation Phase, a Science Confirmation Review will be held to confirm all investigations and the final science payload. Confirmation of investigations will be subject to the following conditions:

1. Adherence to the financial constraints agreed upon. Descoping and/or deselection actions will be taken, as necessary, to stay within these constraints. At the time

of the Science Confirmation Review, the financial impact of each investigation upon spacecraft operations and mission operations will also be evaluated.

2. For investigations involving non-U.S. investigators, a guarantee of adequate support by their respective national funding authorities.

3. Demonstration, for all investigations, that the investigation is compatible with mission constraints, including those of mass, volume, power, configuration, data handling capability, compatibility with other instruments, and (for IDS investigations) compatibility with the instrument payload actually selected.

VIII. CONCLUSION

The Cassini mission is the first purely planetary exploration endeavor undertaken jointly by NASA and ESA. The combination of the Saturn Orbiter with the Huygens Probe provides the opportunity for an indepth, second phase exploration of Saturn and Titan, as well as Saturn's retinue of rings and satellites. The data to be obtained will significantly advance our knowledge of the solar system and its formation and evolutionary processes. I invite you to participate in this important and exciting program.

L. A. Fisk

L. A. Fisk
Associate Administrator for
Space Science and Applications

Enclosures:

1. Appendix A: General Instructions and Provisions
2. Appendix B: Guidelines for Proposal Preparation
3. Appendix C: List of Abbreviations

APPENDIX A
GENERAL INSTRUCTIONS AND PROVISIONS

I. INSTRUMENTATION AND/OR GROUND EQUIPMENT

By submitting a proposal, the investigator and institution agree that NASA has the option to accept all or part of the offeror's plan to provide the instrumentation or ground support equipment required for the investigation, or NASA may furnish or obtain such instrumentation or equipment from any other source as determined by the selecting official. In addition, NASA reserves the right to require use, by the selected investigator, of Government instrumentation or property that subsequently becomes available, with or without modification, that will meet the investigative objectives.

II. TENTATIVE SELECTIONS, PHASED DEVELOPMENT, PARTIAL SELECTIONS, AND PARTICIPATION WITH OTHERS

By submitting a proposal, the investigator and the organization agree that NASA has the option to make a tentative selection pending a successful feasibility or definition effort. NASA has the option to contract in phases for a proposed experiment, and to discontinue the investigative effort at the completion of any phase. The investigator should also understand that NASA may desire to select only a portion of the proposed investigation and/or that NASA may desire the individual's participation with other investigators in a joint investigation, in which case the investigator will be given the opportunity to accept or decline such partial acceptance or participation with other investigators prior to a NASA selection. Where participation with other investigators as a team is agreed to, one of the team members will normally be designated as its team leader or contact point.

III. SELECTION WITHOUT DISCUSSION

The Government reserves the right to reject any or all proposals received in response to this Announcement when such action shall be considered in the best interest of the Government. Notice is also given of the possibility that any selection may be made without discussion (other than discussions conducted for the purpose of minor clarification). It is, therefore, emphasized that all proposals should be submitted initially on the most favorable terms that the offeror can submit.

IV. NON-U.S. PROPOSALS

Guidelines for non-U.S. responses to this Announcement of Opportunity are presented in Appendix B, Section II, paragraph 3. Requirements for PI/Instrument proposals involving U.S./non-U.S. collaboration are summarized below:

1. Non-U.S. Proposals with U.S. Co-I's

In cases where the participation of a U.S. individual is included in a PI/Instrument proposal submitted by a non-U.S. individual, and where it is anticipated that such participation will be supported by NASA, a Management and Cost Plan covering such participation must be submitted to NASA as part of the proposal. This Management and Cost Plan must be signed by the U.S. individual and certified by the U.S. individual's institution. Such costs will be considered in the review and evaluation of proposals submitted by non-U.S. individuals.

2. U.S. Proposals with Non-U.S. Co-I's

Non-U.S. individuals who plan to participate as Co-Investigators on a U.S. PI/Instrument proposal must have such participation reviewed and endorsed by their appropriate governmental agency before such participation can be selected. Evidence of such review and endorsement should be provided at the time that the proposal is submitted or as soon as possible thereafter. Formal arrangements for such participation will be made by NASA's International Relations Division after selection of the investigation.

V. TREATMENT OF PROPOSAL DATA

It is NASA policy to use information contained in proposals and quotations for evaluation purposes only. While this policy does not require that the proposal or quotation bear a restrictive notice, offerors or quoters should, in order to maximize protection of trade secrets or other information that is commercial or financial and confidential or privileged, place the following notice on the title page of the proposal or quotation and specify the information, subject to the notice by inserting appropriate identification, such as page numbers, in the notice. In any event, information (data) contained in proposals and quotations will be protected to the extent permitted by law, but NASA assumes no liability for use and disclosure of information not made subject to the notice.

RESTRICTION ON USE AND DISCLOSURE OF
PROPOSAL AND QUOTATION INFORMATION (DATA)

The information (data) contained in (insert page numbers or other identification) of this proposal or quotation constitutes a trade secret and/or information that is commercial or financial and confidential or privileged. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed for other than

evaluation purposes; provided, however, that in the event a contract is awarded on the basis of this proposal or quotation the Government shall have the right to use and disclose this information (data) to the extent provided in the contract. This restriction does not limit the Government's right to use or disclose this information (data) if obtained from another source without restriction.

VI. STATUS OF COST PROPOSALS (PROPOSALS REQUESTING NASA SUPPORT)

The investigator's institution agrees that the cost proposal submitted in response to this Announcement is for proposal evaluation and selection purposes, and that, following selection and during negotiations leading to a definitive contract, the institution will be required to resubmit or execute Standard Form (SF) Form 1411 "Contract Pricing Proposal Cover Sheet" and all certifications and representations required by law and regulation.

VII. LATE PROPOSALS

The Government reserves the right to consider proposals or modifications thereof received after the date indicated for such purpose, should such action be in the interest of the Government.

VIII. SOURCE OF SPACE INVESTIGATIONS

Investigators are advised that candidate investigations for space missions can come from many sources. These sources include those selected through the Announcement of Opportunity, those generated by NASA in-house research and development, and those derived from contracts and other agreements between NASA and external entities.

IX. DISCLOSURE OF PROPOSALS OUTSIDE GOVERNMENT

NASA may find it necessary to obtain proposal evaluation assistance outside the Government. Where NASA determines it is necessary to disclose a proposal outside the Government for evaluation purposes, arrangements will be made with the evaluator for appropriate handling of the proposal information. Therefore, by submitting a proposal, the investigator and institution agree that NASA may have the proposal evaluated outside the Government. If the investigator or institution desire to preclude NASA from using an outside evaluation, the investigator or institution should so indicate on the cover. However, notice is given that if NASA is precluded from using outside evaluation, it may be unable to consider the proposal.

X. EQUAL OPPORTUNITY (U.S. PROPOSALS ONLY)

By submitting a proposal, the investigator and institution agree to accept the following clause in any resulting contract:

EQUAL OPPORTUNITY

During the performance of this contract, the Contractor agrees as follows:

1. The Contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

2. The Contractor will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to (a) employment; (b) upgrading; (c) demotion; (d) transfer; (e) recruitment or recruitment advertising; (f) layoff or termination; (g) rates of pay or other forms of compensation; and (h) selection for training, including apprenticeship.

3. The Contractor agrees to post in conspicuous places, available to employees and applicants for employment, the notices to be provided by the Contracting Officer that explain this clause.

4. The Contractor shall, in all solicitations or advertisements for employees placed by or on behalf of the Contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

5. The Contractor shall send to each labor union or representative of workers with which it has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the Contracting Officer, advising the labor union or workers' representative of the Contractor's commitments under this clause, and post copies of the notice in conspicuous places available to employees and applicants for employment.

6. The Contractor shall comply with Executive Order 11246, as amended, and the rules, regulations, and orders of the Secretary of Labor.

7. The Contractor shall furnish to the contracting agency all information required by Executive Order 11246, as amended, and by the rules, regulations, and orders of the Secretary of Labor. Standard Form 100 (EEO-1), or any successor form, is the prescribed form to be filed within 30 days following the award, unless filed within 12 months preceding the date of award.

8. The Contractor shall permit access to its books, records, and accounts by the contracting agency or the Office of Federal Contract Compliance Programs

(OFCCP) for the purposes of investigation to ascertain the Contractor's compliance with the applicable rules, regulations, and orders.

9. If the OFCCP determines that the Contractor is not in compliance with this clause or any rule, regulation, or order of the Secretary of Labor, the contract may be cancelled, terminated, or suspended in whole or in part, and the Contractor may be declared ineligible for further Government contracts, under the procedures authorized in Executive Order 11246, as amended. In addition, sanctions may be imposed and remedies invoked against the Contractor as provided in Executive Order 11246, as amended, and by the rules, regulations, and orders of the Secretary of Labor, or as otherwise provided by law.

10. The Contractor shall include the terms and conditions of subparagraph 1 through 9 of this clause in every subcontract or purchase order that is not exempted by the rules, regulations, or orders of the Secretary of Labor issued under Executive Order 11246, as amended, so that these terms and conditions will be binding upon each subcontractor or vendor.

11. The Contractor shall take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing these terms and conditions, including sanctions for noncompliance; provided, that if the Contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of direction, the Contractor may request the United States to enter into the litigation to protect the interests of the United States.

XI. PATENT RIGHTS

1. For any contract resulting from this solicitation awarded to other than a small business firm or nonprofit organization, the clause at NFS 18-52.227-70, "New Technology," shall apply. Such contractors may, in advance of contract, request waiver of rights as set forth in the provision at NFS 18-52.227-73, "Requests for Waiver of Rights to Inventions."

2. For any contract resulting from this solicitation awarded to a small business firm or nonprofit organization, the clause at FAR 522.227-11, "Patent Rights--Retention by the Contractor (Short Form)" (as modified by NFS 18-52.227-11), and the clause at NFS 18-52.227-73, "Patent Rights Clause for Subcontracts," shall apply.

APPENDIX B
GUIDELINES FOR PROPOSAL PREPARATION

The following guidelines apply to the preparation of proposals by potential investigators in response to an Announcement of Opportunity. The material presented is merely a guide for the prospective proposer, and it is not intended to be all encompassing or directly applicable to the various types of proposals which can be submitted. The proposer should, however, provide information relative to those items applicable or as otherwise required by the Announcement of Opportunity. Specific procedures and details for each of the three types of proposals invited by this Announcement of Opportunity are described in Volume I of the Proposal Information Package.

A. COVER LETTER

A letter or cover page should be forwarded with the proposal. It should be signed by the investigator and an official by title of the investigator's organization who is authorized to commit the organization that is responsible for the proposal and its contents.

B. TABLE OF CONTENTS

The proposal should contain a table of contents.

C. IDENTIFYING INFORMATION

The proposal should contain a short descriptive title for the investigation, the names of all investigators, and the name of the organization or institution. The full name of the Principal Investigator, address with zip code, and telephone number should be included.

I. INVESTIGATION AND TECHNICAL PLAN

A. INVESTIGATION AND TECHNICAL PLAN

The investigation and technical plan generally will contain the following:

1. Summary. A simple, concise statement about the investigation, its conduct, and the anticipated results.

2. Objectives and Significant Aspects. A brief definition of the objectives, their value, and their relationships to past, current, and future efforts. The history and basis for the proposal and a demonstration of the need for such an investigation. A statement of present development in the discipline field.

3. Investigation Approach.

a. Fully describe the concept of the investigation.
b. Detail the method and procedures for carrying out the investigation.

B. INSTRUMENTATION

This section should describe all information necessary to plan for experiment development, integration, ground operations, and flight operations. This section must be complete in itself without the need to request additional data. Failure to furnish complete data may preclude evaluation of the proposal.

1. Instrument Description. This section should fully describe the instrumentation and indicate items which are proposed to be developed, as well as any existing instrumentation. Performance characteristics should be related to the experiment objectives as stated in the proposal.

2. Instrument Integration. This section should describe all parameters of the instrument pertinent to the accommodation of the instrument in the spacecraft. These include, but are not limited to: volumetric envelope, weight, power requirements, thermal requirements, telemetry requirements, sensitivity to or generation of contamination (e.g., electromagnetic interference, gaseous effluents), data processing requirements.

3. Ground Operations. This section should identify requirements for prelaunch or postlaunch ground operations support.

4. Flight Operations. This section should identify any requirements for flight operations support including mission planning. Operational constraints, viewing requirements, and pointing requirements should also be identified. Describe any special communications, tracking, or near real-time ground support requirements and indicate any special equipment or skills required of ground personnel.

C. DATA REDUCTION AND ANALYSIS

A discussion of the data reduction and analysis plan including, insofar as possible, the method and format. A section of the plan should include a schedule for the submission of reduced data to the receiving point as specified in this Announcement of Opportunity.

II. MANAGEMENT AND COST PLAN

A. MANAGEMENT PLAN

The management plan should summarize the management approach and the facilities and equipment required. Additional guidelines applicable to non-U.S. proposers are contained herein.

1. Management

a. The management plan sets forth the investigator's approach for managing the work, the recognition of essential management functions, and the overall integration of these functions.

b. The management plan gives insight into the organization proposed for the work, including the internal operations and lines of authority with delegations, together with internal interfaces and relationships with NASA, major subcontractors, and associated investigators. Likewise, the management plan usually reflects various schedules necessary for the logical and timely pursuit of the work, accompanied by a description of the investigator's work plan and the responsibilities of the Co-Investigators.

c. The plan should describe the proposed method of instrument acquisition. Specifically, it should include the following, as applicable:

(1) Rationale for the investigator to obtain the instrument through or by the investigator's institution.

(2) Method and basis for the selection of the proposed instrument fabricator.

(3) Unique or proprietary capabilities of the instrument fabricator that are not available from any other source.

(4) Contributions or characteristics of the proposed fabricator's instrument that make it an inseparable part of the investigation.

(5) Availability of supporting personnel in the institution to successfully administer the instrument contract and technically monitor the fabrication.

(6) Status of development of the instrument, e.g., what additional development is needed. Areas that need further design or in which unknowns are present.

(7) Method by which the investigator proposes to:

(a) Prepare instrument hardware and software specifications.

(b) Review development progress.

(c) Review design and fabrication changes.

(d) Participate in testing program.

(e) Participate in final checkout and calibration.

(f) Provide for integration of instrument.

(g) Support the flight operations.

(h) Coordinate with Co-Investigators, other related investigations, and the payload integrator.

(i) Assure safety, reliability, and quality.

(8) Planned participation by small and/or minority business in any subcontracting for instrument fabrication or investigative support functions.

2. Facilities and Equipment

All major facilities, laboratory equipment, and ground-support equipment (GSE) (including those of the investigator's proposed contractors and those of NASA and other U.S. Government agencies) essential to the experiment in terms of its system and subsystems are to be indicated, distinguishing insofar as possible between those already in existence and those that will be developed in order to execute the investigation. The outline of new facilities and equipment should also indicate the lead time involved and the planned schedule for construction, modification, and/or acquisition of the facilities.

3. Additional Guidelines Applicable to Non-U.S. Proposers Only

The following guidelines are established for non-U.S. responses to NASA's Announcement of Opportunity. Unless otherwise indicated in a specific announcement, these guidelines indicate the appropriate measures to be taken by non-U.S. proposers, prospective non-U.S. sponsoring agencies, and NASA leading to the selection of a proposal and execution of appropriate arrangements. They include the following:

a. Where a "Notice of Intent" to propose is requested, prospective non-U.S. proposers should write directly to the NASA official designated in the Announcement of Opportunity and send a copy of this letter to the International Relations Division, Office of External Relations, Mail Code XID, National Aeronautics and Space Administration, Washington, DC 20546, U.S.A.

b. Unless otherwise indicated in the Announcement of Opportunity, proposals will be submitted in accordance with this Appendix (excluding Cost Plans). Proposals must be typewritten and in English.

c. Persons planning to submit a proposal should arrange with an appropriate non-U.S. governmental agency for a review and endorsement of the proposed activity. Such endorsement by a non-U.S. organization indicates:

1) The proposal merits careful consideration by NASA.

2) If the proposal is selected, sufficient funds will be available to undertake the activity envisioned.

d. Proposals in the requested number of copies and letters of endorsement from the non-U.S. governmental agency must be forwarded to NASA in time to arrive before the deadline established for each Announcement of Opportunity. The endorsed original of the proposal should be sent to:

International Relations Division
Office of External Relations
Mail Code XID (A.O. No. OSSA-1-89)
National Aeronautics and Space Administration
Washington, DC 20546
U.S.A.

The additional copies of the proposal should be forwarded directly to the Program Office specified in the Announcement of Opportunity.

e. All proposals must be received before the established closing date and time; those received after the closing date will be treated in accordance with NASA's provisions for late proposals. Sponsoring non-U.S. government agencies may, in exceptional situations, forward a proposal directly to the above address if review and endorsement are not possible before the announced closing date. In such cases, NASA should be advised when a decision on endorsement can be expected.

f. Shortly after the deadline for each Announcement of Opportunity, NASA's International Relations Division will advise the appropriate sponsoring agency which proposals have been received and when the selection process should be completed. A copy of this acknowledgement will be provided to each proposer.

g. Successful and unsuccessful proposers will be contacted directly by the NASA Program Office coordinating the Announcement of Opportunity. Copies of these letters will be sent to the sponsoring government agency.

h. NASA's International Relations Division will then begin making the necessary arrangements to provide for the selectee's participation in the appropriate NASA program. Depending on the nature and extent of the proposed cooperation, these arrangements may entail:

(1) A letter of notification by NASA.

(2) An exchange of letters between NASA and the sponsoring non-U.S. governmental agency.

(3) An agreement or Memorandum of Understanding between NASA and the sponsoring non-U.S. governmental agency.

B. COST PLAN (PROPOSALS REQUESTING NASA SUPPORT)

The cost plan should summarize by Government Fiscal Year (October 1 to September 30) the total investigation cost by major categories of cost as well as by function.

1. The categories of cost should include the following:

a. Direct Labor. List by labor category, with labor-hours and rates for each. Provide actual salaries of all personnel and the percentage of time each individual will devote to the effort.

b. Overhead. Include indirect costs which, because of their incurrence for common or joint objectives, are not readily subject to treatment as a direct cost. Usually this is in the form of a percentage of the direct labor costs.

c. Materials. This should give the total cost of the bill of materials, including estimated cost of each major item. Include lead time of critical items.

d. Subcontracts. List those over $25,000, specify the vendor and the basis for estimated costs. Include any baseline or supporting studies.

e. Special Equipment. Include a list of special equipment with lead and/or development time. Include number of units and types.

f. Travel. List estimated number of trips, destinations, duration, purpose, number of travelers, and anticipated dates.

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g. Other Costs. Costs not covered elsewhere.

h. General and Administrative Expense. This includes the expenses of the institution's general and executive offices and other miscellaneous expenses related to the overall business.

i. Fee (if applicable).

2. Separate schedules, in the above format, should be attached to show total cost allocable to the following by Government Fiscal Year:

a. Principal Investigator and other Investigator Costs for Science Support. The science support category includes all efforts associated with overall investigation management; support of the Cassini PSG; the development of calibration requirements (but not calibration itself); the planning for the mission operations/data analysis phase, including necessary prelaunch development of ground software required only for postlaunch activities. This category begins on October 1, 1990, and ends on May 15, 1996 (approximately launch plus 30 days).

b. Hardware Costs. The hardware category consists of all efforts, including field support at JPL, associated with the design, fabrication, test, calibration, operation and maintenance of the flight instrument(s) and a suitable complement of spare components (and functional or nonfunctional models such as Engineering Models and Temperature Control Models as required by the Project); the design, development, test, operation, and maintenance of instrument ground support equipment; the design, test, and maintenance of instrument and support equipment software; support to the Project regarding matters related to the integration of the flight instrument with the spacecraft; and the engineering management of the foregoing efforts. This category begins on October 1, 1990, and ends on May 15, 1996.

c. Mission Operations/Data Reduction and Analysis Costs. The mission operations/data analysis phase includes all costs associated with the investigation beginning on May 16, 1996, including support of the PSG, mission operations, computer time, and data reduction, analysis, and archiving. As with science support, it also includes investigator support of the PSG working groups, but in the period after May 16, 1996, until December 31, 2007.

3. If the effort is sufficiently known and defined, a funding obligation plan should provide the proposed funding requirements of the investigations by annum keyed to the work schedule.

APPENDIX C

LIST OF ABBREVIATIONS

ALT	Nadir looking altimeter. A RADAR mode.
AO	Announcement of Opportunity
AU	Astronomical Unit. Distance from the Sun to the Earth.
CCD	Charge Coupled Device
Co-I	Co-Investigator on PI/Instrument Investigation
COMPLEX	Committee on Planetary and Lunar Exploration
CRAF	Comet Rendezvous Asteroid Flyby
DSN	Deep Space Network
ESA	European Space Agency
ESTEC	European Space Research and Technology Centre
FRG	Federal Republic of Germany
FY	Fiscal Year
GHz	GigaHertz. A radio frequency in billions of cycles per second.
GSE	Ground Support Equipment
HGA	High Gain Antenna
HPSP	High Precision Scan Platform
IDS	Interdisciplinary Scientist
IDT	Instrument Development Team. For Facility Instruments.
IFOV	Instantaneous Field of View
ISS	Imaging Science Subsystem. A candidate Facility Instrument.
JPL	The Jet Propulsion Laboratory, Pasadena, CA.
JSWG	Joint Science Working Group

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JWG	Joint Working Group
kbps	Kilobits per second. A data transmission rate.
LGA	Low Gain Antenna
Mb	Megabits
MBI	Multi-beam imaging radar. A RADAR mode.
MHz	MegaHertz. A radio frequency in millions of cycles per second.
MM II	Mariner Mark II
MOS	Mission Operations System
mps	Meters per second
MSA	Mission Support Area
NASA	National Aeronautics and Space Administration
PI	Principal Investigator on a PI/Instrument Investigation
PIDDP	Planetary Instrument Definition and Development Program
PMS	Propulsion Module Subsystem
PS	Participating Scientist
PSG	Project Science Group
PSS	Probe Support Subsystem
RADAR	Titan Radar Mapper. A candidate Facility Instrument.
RAM	Ram Direction Platform
RFS	Radio Frequency Subsystem
R_J	Radius of Jupiter
RMS	Root mean square
R_S	Radius of Saturn
RSS	Radio Science Subsystem. A candidate Facility Instrument.

RTG	Radioisotope Thermoelectric Generator
SAR	Synthetic aperture radar. A RADAR mode.
SCAT	Nadir-looking scatterometer. A RADAR mode.
SDF	Supplementary Data File
SFOC	Space Flight Operations Center. A JPL Facility.
SKR	Saturn Kilometric Radiation
SOI	Saturn Orbit Insertion
SOPC	Science Operations and Planning Computer
SOU	RADAR sounder mode
SPC	Science Programme Committee of ESA
SSAC	Space Science Advisory Committee of ESA
SSASC	Space Science and Applications Steering Committee
SSEC	Solar System Exploration Committee
TL	Team Leader of a Facility Instrument Team
TM	Team Member of a Facility Instrument Team
VIMS	Visual and Infrared Mapping Spectrometer. A candidate Facility Instrument.

*U.S. GOVERNMENT PRINTING OFFICE:1989-241-466:00051

NASA Mailing List Update

This is the update form for the NASA Office of Space Science and Applications Scientific Investigation mailing list. If applicable, please fill out all the following information, refold the questionnaire, tape it, and mail it back to the preprinted address on the reverse side.

Please check the type of NASA Mailings you would like to receive (check all that apply):

- ☐ 1. Announcements of Opportunity
- ☐ 2. Space Science and Applications Notices
- ☐ 3. NASA Research Announcements (NRA)

Please check one:

- ☐ Please **add** my name to the NASA Mailing List
- ☐ Please **remove** my name from NASA Mailing List
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Institution type (check all that apply)

- ☐ 1. College or University
- ☐ 2. International
- ☐ 3. Minority Business
- ☐ 4. NASA Center
- ☐ 5. Nonprofit Corporation
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- ☐ 7. Private Industry
- ☐ 8. Small Business

Discipline (check all that apply)

- ☐ 1. Astronomy
- ☐ 2. Communications
- ☐ 3. Computer Sciences/ Information Systems
- ☐ 4. Environmental Observations
- ☐ 5. Life Sciences
- ☐ 6. Microgravity Sciences
- ☐ 7. Planetary Sciences
- ☐ 8. Solar and Space Physics

Program Involvement (check all that apply)

- ☐ 1. Principal Investigator
- ☐ 2. Co-Investigator
- ☐ 3. Management/Administration
- ☐ 4. General Interest
- ☐ 5. Flight Project
- ☐ 6. Suborbital Investigation
- ☐ 7. Data Analysis
- ☐ 8. Basic Research
- ☐ 9. Advanced Planning and Mission Definition
- ☐ 10. Science Working Group
- ☐ 11. American Astronomical Society Member

OSSA Involvement (check all that apply)

- ☐ 1. Astrophysics
- ☐ 2. Communications and Information Systems
- ☐ 3. Earth Science and Applications
- ☐ 4. Life Sciences
- ☐ 5. Microgravity Science and Applications
- ☐ 6. Shuttle Payload Engineering
- ☐ 7. Solar System Exploration
- ☐ 8. Space Physics
- ☐ 9. None

NASA Contractor/Grantee: ☐ Yes ☐ No

(If YES, please provide current NASA/OSSA Contract & Grant Numbers and Designate Level of Responsibility)

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